PRIL 1961
LUME 4 • NUMBER 4

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the microwave journal

ROBERT H MAIER
KELLOGG SWITCHBOARD &
SUPPLY CO CHICAGO
6 18 39, ILLINOIS

500 No. Pulaski

In This Issue . . .

1961 PGMTT NATIONAL SYMPOSIUM PROGRAM

1 µw to 10 mw coverage, in power meter ever produced!

This new hp Power Meter makes continual zero-setting a thing of the past, even on the 10 µw range, with extreme temperature stability and a single zero-set covering all 7 ranges. You get a completely usable 10 db sensitivity premium over previously available equipment.

New, specially designed temperature compensated thermistor mounts are used with the hp 431A. The hp 478A Coaxial Mount covers 10 MC to 10 GC, and the hp X486A Waveguide Mount covers X-Band.

A dual balanced bridge technique and careful design and construction keep dc power in one bridge equal to the unknown rf power in the other. The dc power is then metered. High heat conductivity materials and matched thermistors in close proximity in the 478A and 486A mounts provide extremely close thermal tracking. Thus ambient temperature effects are automatically balanced out and the meter remains zeroed, even in the presence of thermal shock.

These advantages combine to make the hp 431A unusually useful for instantaneous microwave power measurements. Microwave power standards measurements can be made to a high accuracy and resolution by using the dual bridge of the hp 431A as a transfer device. A dc calibration input jack permits precise dc calibration of the thermistor mount. The grounded output jack will then drive an appropriate digital voltmeter for increased resolution. In addition, the grounded output jack, combined with the nearly drift free operation of the 431A, makes reliable long term recordings of microwave power.

The hp 431A also has an optional rechargeable battery pack which will give up to 24 hours of completely portable operation, as well as regular ac line operation while recharging.

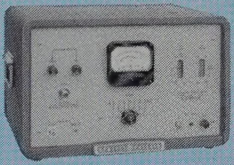
SPECIFICATIONS

Power Range:	10 µw to 10 mw full scale in 7 ranges. Also calibrated from −30 to +10 dbm
Accuracy:	±3% of full scale on all ranges
Overall Thermal Drift:	Less than 2 µw/°C (includes meter and 478A/486A Mounts)
Operating Impedance:	100 or 200 ohms, negative, for operation with above Mounts
Recorder/Voltmeter Output:	Phone jack on rear with 1 ma into 2,000 ohms or less
Calibration Input:	Binding posts on rear for calibration of bridge with precise dc standards
Power:	1½ watts, 115/230 v ± 10%, 50-1000 cps
Dimensions:	7½" wide, 6½" high, 12½" deep. Weight 10 lbs.
Price:	$345.00

or perhaps your power measuring requirements can be met by these hp meters

hp 430C Microwave Power Meter — 0.02 to 10 mw

This laboratory-proven meter gives instantaneous rf power readings direct in dbm or mw, 10 MC to 40 GC with hp proven bolometer mounts available now. hp 430C operates with any bolometer operating at 100 or 200 ohms, positive or negative temperature coefficient. Fully adjustable biasing current to 16 ma available to bring bolometers to their operating range. Five power ranges are selected with a front-panel control, full scale readings of 0.1, 0.3, 1, 3 and 10 mw. Also continuous readings —20 to +10 dbm. Accuracy is ±5% of full scale reading. Dimensions, (cabinet) 7½" x 11½" x 14"; (rack mount) 19" x 7" x 13½" behind panel. Price, hp 430C $250.00 (cabinet); hp 430CR, $255.00 (rack mount).



hp 434A Calorimetric Power Meter — 10 mw to 10 w

Here's the fastest, easiest means yet devised to measure powers accurately from 10 mw to *10 w*, dc to 12.4 GC! No barretter, thermistor, external terminations or plumbing are required. Measurements are as simple as connecting to a 50 ohm type N front panel terminal and reading directly. Only two front panel controls (range and zero); seven meter ranges for full scale readings of 0.01, 0.03, 0.1, 0.3, 1.0, 3.0 and 10 w. Also provides continuous readings —30 to +10 dbw. Accuracy ±5% of full scale (includes dc calibration and rf termination efficiency but not mismatch loss). Greater accuracy can be achieved through appropriate techniques. Dimensions, (cabinet) 20½" x 12½" x 14¾"; (rack mount) 19" x 10½" x 13½". Price, hp 434A, $1600.00 (cabinet); hp 434AR, $1,585.00 (rack mount).

HEWLETT-PACKARD COMPANY
1069C Page Mill Road Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000
Sales representatives in all principal areas

HEWLETT-PACKARD S. A.
Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

Data subject to change without notice. Prices f.o.b. factory

AT NEW FRONTIERS...

in . . . Space Research

and . . . The Application of
Recently Obtained Scientific Data

RESEARCH AND DEVELOPMENT

DESIGN ENGINEERS

TO PROVIDE TECHNICAL SUPPORT ON SPACE VEHICLE PROJECTS INVOLVING design integration of sub-systems, such as, programming units, receiving systems, reference generators, modulators, antennas, and telemetering equipment.

EXPERIENCED IN THE DESIGN OF

- Transistor amplifiers and video circuits for space probe applications.
- Data processing and display circuits for advanced concepts in ground based communication and radar systems.

ADVANCED TECHNIQUE DEVELOPMENT ENGINEERS

TO DEVELOP ferrite devices, parametric amplifiers, masers and other microwave solid state devices.

PROJECT ENGINEERS

BSEE REQUIRED. MSEE DESIRED. MINIMUM OF FIVE YEARS' EXPERIENCE. Needed immediately are men with experience in Radar, Data Processing, and Data Display systems. Must be able to integrate and optimize complex systems. Must be capable of providing engineering direction on microwave systems for Navigation and Tracking. Experience in the design of low noise receiving systems is highly desirable. Efforts are related to Polaris and Deep Space Probe Programs.

Boston Location • Liberal Company Benefits

For personal interview send resume, or call Mr. James J. Wright, OLympic 3-3300

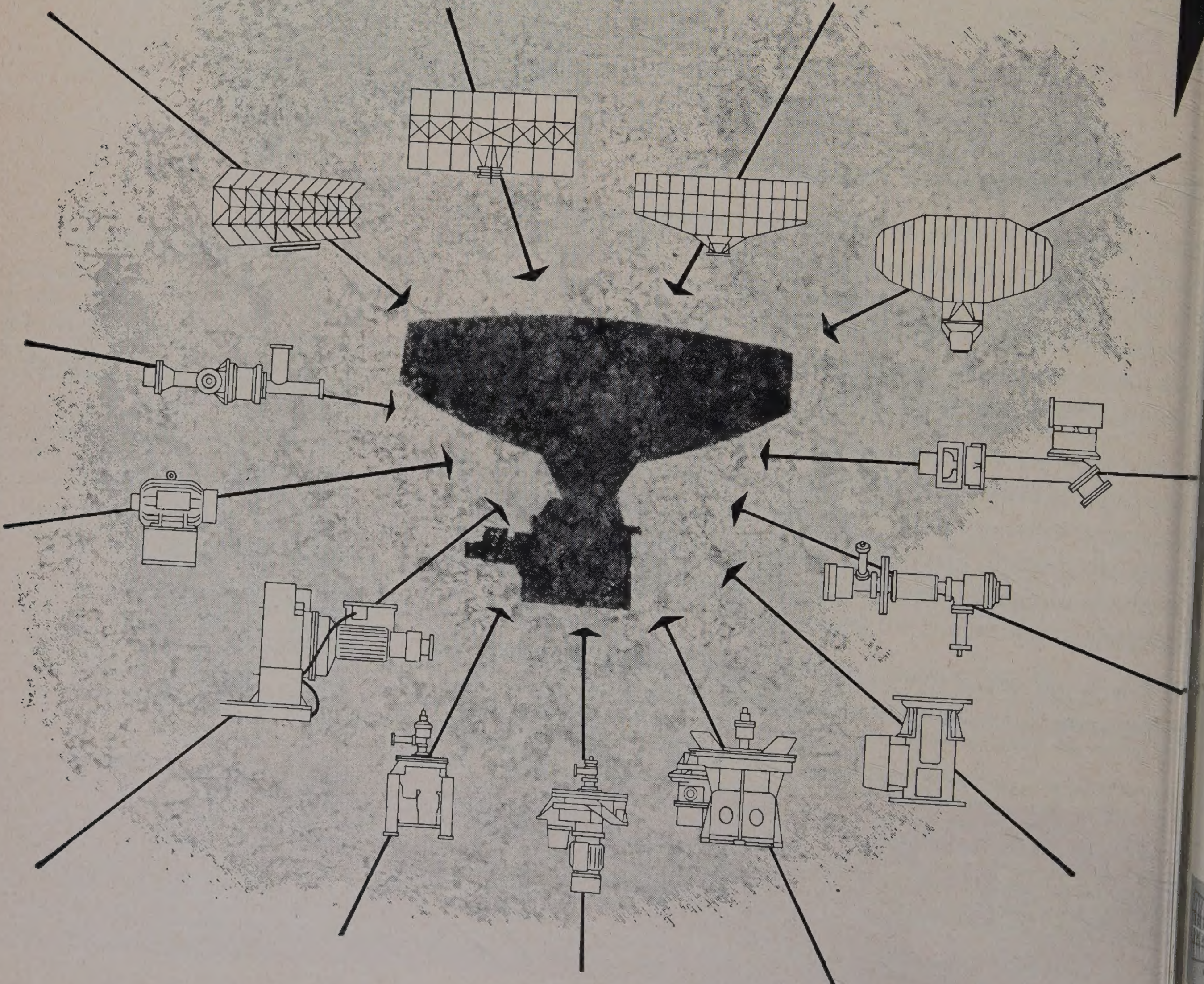
Ewen Knight CORPORATION

AT NEW FRONTIERS IN *Electronics*

EAST NATICK, MASS.
OLympic 3-3300

The **I-T-E Modular** design concept
applied to radar antenna systems
permits a wide latitude in the
choice of interchangeable antennas,
**rotary joints, pedestals, drives
and associated component combinations.**
all components have been field tested
and proved under every service condition.

One of the many advantages of the modular concept is...



RELIABILITY

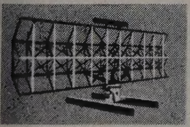
with I-T-E modular radar antennas

There is only one positive and dependable test for any radar system or component . . . actual field service. No laboratory can foresee every combination of weather, temperature and wind lashing that may be encountered in actual operation.

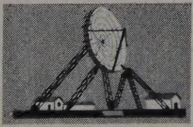
The reliability of I-T-E modular-design radar components has been proved through years of service under every severe environmental condition. Such components however combined, can be depended upon to meet exacting operational requirements.

The modular radar antenna concept by I-T-E is your assurance of continuous operation in every climate. The flexibility of modular design also permits meeting your specifications with a minimum in time, engineering and tooling. Write to I-T-E Circuit Breaker Company, Special Products Division, Dept. MJ 601 E. Erie Ave., Phila. 34, Pa., or call GArfield 6-5700.

I-T-E CIRCUIT BREAKER COMPANY
SPECIAL PRODUCTS DIVISION

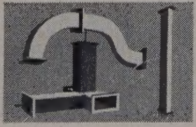


RADAR ANTENNA SYSTEMS



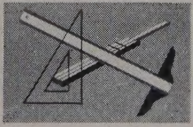
UHF ANTENNA SYSTEMS

PEDESTALS DRIVES • CONTROLS



WAVEGUIDES & COMPONENTS

RESEARCH & DEVELOPMENT



DESIGN & ENGINEERING

PRECISION MANUFACTURING

Circle Reader Service Card 2

MICROVIEWS OF THE MONTH

57 ▶ THE LINCOLN LABORATORY ANTENNA TEST RANGE

Albert Cohen and A. W. Maltese

This article describes the important features of the Lincoln Laboratory Antenna Test Range which utilizes the ground level principle to obtain a plane wave incident on the test antenna aperture. A discussion of the design considerations and a description of the site preparation, equipment, and instrumentation are included. In addition, test range performance data are presented.

66 ▶ THERMAL NOISE IN MICROWAVE SYSTEMS — PART II

A. E. Siegman

This article first considers briefly the general problem of describing the noise performance of an amplifier, especially when the amplifier is of a bilateral or negative-resistance type. It then considers noise in maser amplifiers: first the noise generation mechanism in maser spin systems, and then the theoretical noise figures of cavity and traveling-wave masers.

74 ▶ STANDARDIZATION OF RIDGED WAVEGUIDES

Tore N. Anderson and Leonard I. Kent

This paper reviews the program to provide industry standards for ridged waveguides, for wide band systems applications, over the frequency range from 175 to 40,000 megacycles. These proposed standards developed through the Electronics Industries Association Engineering Department provide two overlapping series, one having a 2.4 to 1 frequency coverage per waveguide and the other a 3.6 to 1. The waveguides designed are directly scalable from one size to another, greatly simplifying ridged waveguide component development.

79 ▶ A SIMPLE APPROXIMATE EXPRESSION FOR CONVERTING DIRECTLY FROM NOISE FIGURES IN DB TO NOISE TEMPERATURES

E. P. McCurley and C. Blake

An approximate expression is given for converting directly from noise figures in decibels to noise temperatures. The expression is accurate to within 4% for noise figures of 3 db or less. It should prove of value to those workers in the field of low noise devices who frequently perform conversions from noise figures in decibels to noise temperatures, or vice versa. The relationships given may be easily memorized and are readily solved by means of mental arithmetic or only a pencil and a piece of paper.

81 ▶ MEASURING HIGH POWER BREAKDOWN

Gershon Wheeler

This paper discusses methods of measuring breakdown when there is no suitable high power source available.

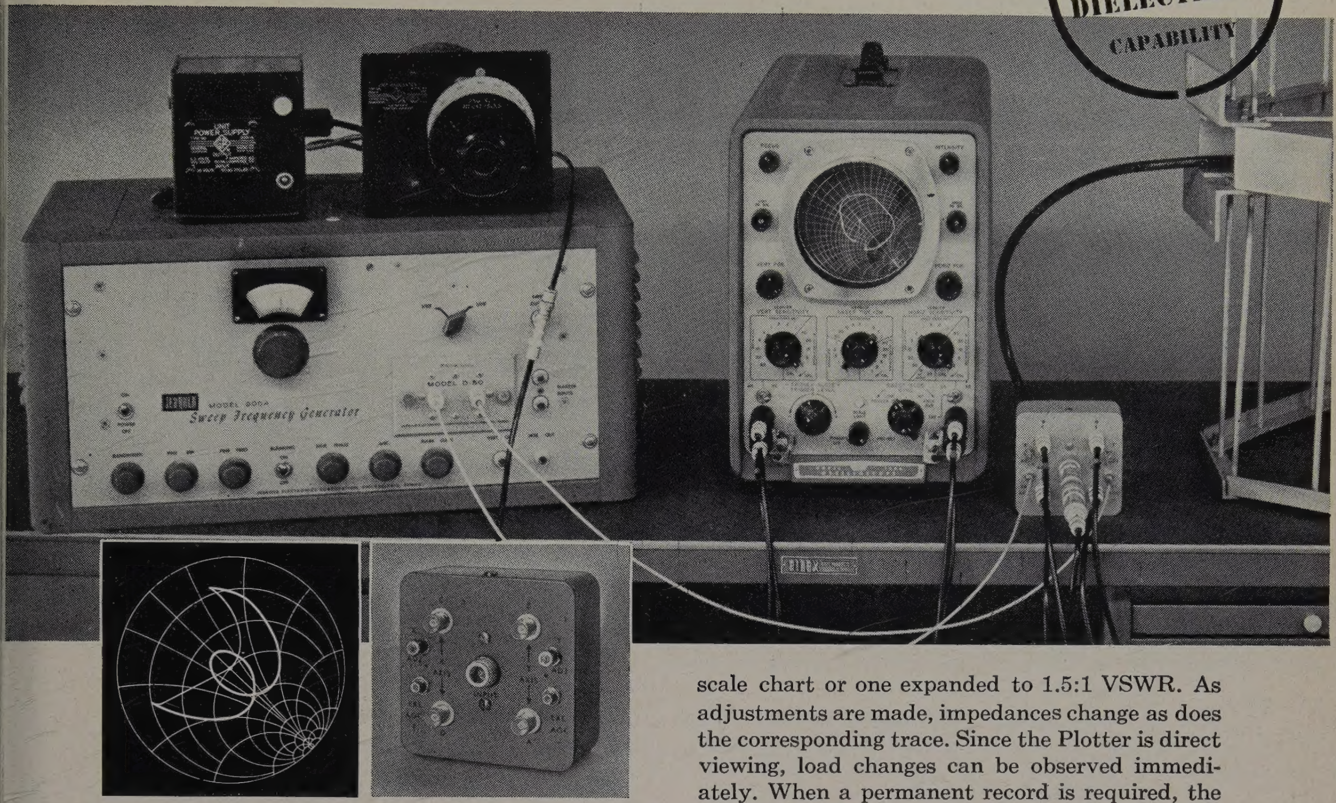
OUR COVER

The 84-foot diameter antenna of M.I.T. Lincoln Laboratory's Millstone Hill Radar Station has seen increasing use in the fields of radar astronomy and ionospheric studies. The very vital achievement of low receiver noise temperatures by maser and parametric amplifier techniques has made the calculation of overall system noise temperature an important everyday task at Millstone. Such calculations are simplified by means of an expression for converting from noise figures in db to noise temperatures in degrees Kelvin that is given in the article on page 79.

the
microwave
journal

'he best way yet to measure complex impedances

ANOTHER
MEASURE OF
DIELECTRIC'S
CAPABILITY



Here — for the first time — is an approach to the measurement of complex impedance over a band of frequencies that, for speed, simplicity and reliability, surpasses anything yet used.

It's the Smith Chart Plotter, specially developed by Dielectric Products Engineering Company to obtain instantaneous display of impedance as a continuous function of frequency. There are five coupler models spanning 10 to 3000 mc/s.

This unique coupler — along with appropriate auxiliary equipment to form the complete plotter — eliminates the need to tie up highly skilled technical personnel during prolonged test routines that characterize slotted line measurements. As precise as it is versatile and easy to operate, the Plotter functions simply and quickly to deliver peak accuracies.

HOW IT WORKS

With Dielectric's Smith Chart Coupler, a sweep generator sweeps over the frequency band of the unknown load. A continuous trace of impedance versus frequency is displayed directly on the Smith Chart faceplate. This can be either a full scale chart or one expanded to 1.5:1 VSWR. As adjustments are made, impedances change as does the corresponding trace. Since the Plotter is direct viewing, load changes can be observed immediately. When a permanent record is required, the oscilloscope trace may be directly photographed. Or, if preferred, an X-Y chart recorder may be used.

If you're a designer looking for a faster, easier way to obtain more accurate impedance and admittance measurements of diverse components such as antennas, filters, load resistors, transformers and other r-f networks, you'll find the Smith Chart Plotter one of your most essential tools.

For complete description and for details of operation of the Smith Chart Plotter, write for Bulletin 60-3.

SPECIFICATIONS (ALL MODELS)

Nominal impedance	50 ohms
RF input voltage	0.2 volts, rms
Oscillograph signal voltage	
(0.1 volt input to plotter)	40 millivolts x reflection coefficient
Accuracy of reflection coefficient measurement	
a. Amplitude	± 5% of reflection coefficient ± 0.01
b. Phase	± 3 degrees ± arc tan $\left(\frac{.01}{\text{reflection coeff.}}\right)$
Sweep rate (maximum)	60 sps
Spot rotation rate (maximum for full accuracy)	1000 rev/sec
RF input and output terminals	Type N female
Oscilloscope signal terminals (balanced)	Type BNC female
Automatic level control terminals	Amphenol Series 27 female

Other areas of **DIELECTRIC** capability in coaxial, waveguide and open wire techniques . . .

TRANSMISSION LINE & COMPONENTS • NETWORKS
SWITCHES • TEST EQUIPMENT • R&D ENGINEERING

dial DIELECTRIC
for solutions to
communications
problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

THE PGMTT SYMPOSIUM

Although we do not make it a practice of catering to specific events during the year in the form of special issues of *the microwave journal*, it would be hard to disguise the fact that this is the PGMTT Symposium issue.

It is probably true that without a PGMTT there may never have been a *microwave journal.* One substantiating fact is that most of the members of our editorial staff have been active in either the local or national level of PGMTT. All, at one time or another, have actively participated in one of the annual symposiums.

In addition to our editorial staff there are our friends, critics, and benevolent advisors who have, through the years, helped us in many ways. Many of them are also active in PGMTT.

One of our staunchest critics and avid advisors has been Gus Shapiro, of the National Bureau of Standards, this year's technical program committee chairman. From the period before we published our first issue to the present he has taken a great interest in our activities. In fact, many of his ideas and suggestions have been of value to us in our steady growth.

Having participated as a member of the technical program committee this year, I had an opportunity to observe his tremendous organizational drive at first hand. We had what must have been one of the most efficiently run and carefully organized committees. We were *enveloped* in what could be called an aura of dynamic efficiency.

Many people have worked hard on this year's program. The only reason for not mentioning them is that my major contact has been with Gus Shapiro: and, frankly, I have been impressed. The technical program should be one of the finest we have had in the history of PGMTT. In fact, judging from the hard work and careful preparations on the part of the whole symposium committee, headed by Bob Stone of NBS, this promises to be one of the best on all counts. Significantly, this will be the first PGMTT Symposium that will supply a complete technical digest to each attendee before the sessions begin.

I would also like to call your attention to the evening programs. They promise to be both informative and entertaining.

Since we have admittedly weakened and made this the PGMTT issue, I would like to mention that we have printed the complete technical program in this issue. Also, for those of you who would like to take advantage of advance registration, the complete form is printed on page 131.

Many people will miss the Del Coronado and the San Diego sunshine, but this is the year of the great intellectual migration to Washington. Why should PGMTT be different!

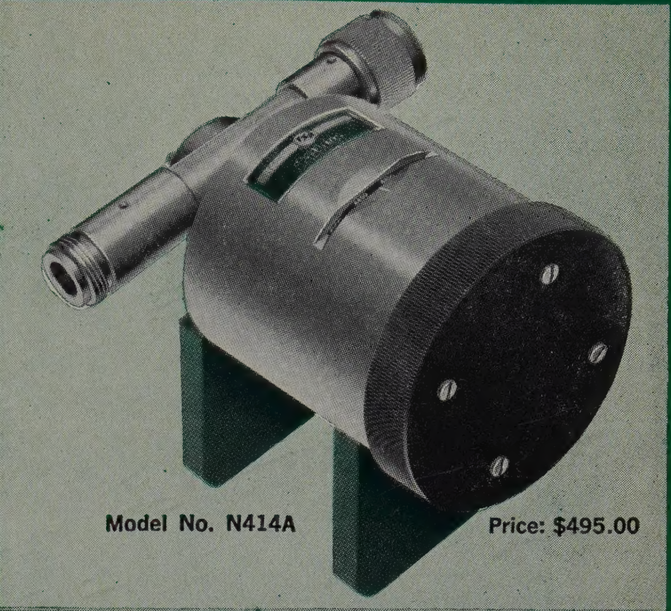
Ted Saad

NEW!
DIRECT READING FREQUENCY METER

a full octave and beyond

3.95 to 11.0 KMc

DELIVERY FROM STOCK


Model No. N414A
Price: $495.00

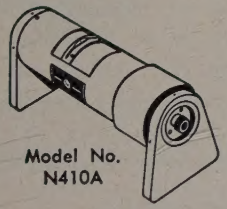
- Direct reading from 3.95 to 11.0 KMc
- Covers a full octave and beyond
- Reaction type with 0.1% absolute accuracy
- Non-contacting choke for long life and high Q
- Standard Type N Connectors for universal utilization

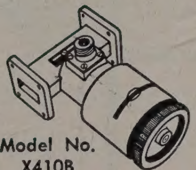
Meet the newest member of the FXR "family" of direct reading frequency meters. This coaxial type, Model No. N414A, has a range from 3.95 KMc to 11.0 KMc and by use of FXR Series 601 coax to waveguide adapters converts to waveguide set-ups. The unit covers "a full octave and beyond" with an absolute accuracy of 0.1% throughout its range. It is a perfect companion for the FXR Models No. C772 and X772 signal sources.

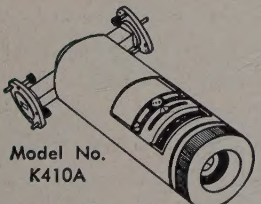
This newest direct reading frequency meter augments FXR's existing line, recognized as the largest in the industry. Direct reading, reaction type units are available for use up to 39.5 KMc while micrometer types extend FXR's coverage up to 220 KMc.

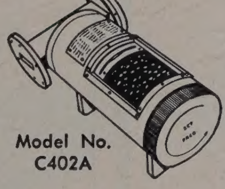
Write or call now for data sheets on Model No. N414A and other units in the integrated FXR family of precision frequency meters.

FXR "FAMILY" OF DIRECT READING REACTION TYPE FREQUENCY METERS


Model No.
N410A


Model No.
X410B


Model No.
K410A


Model No.
C402A

Model No.	Frequency Range (KMc)	Absolute Accuracy (%)	Approx. Q	Waveguide Type RG-( )/U	Flange Type UG-( )/U	Price (F.O.B. Woodside)
COAXIAL TYPES						
N410A	1.00- 4.00	0.10	3000	(3/8" Coax Type N)		$495.00
N414A	3.95-11.0	0.10	500 to 1500	(3/8" Coax Type N)		495.00
WAVEGUIDE TYPES						
*H410B	3.95- 5.85	0.08	8000	49	149A	250.00
*C410B	5.85- 8.20	0.08	8000	50	344	180.00
*W410B	7.05-10.00	0.08	8000	51	51	165.00
*X410B	8.20-12.40	0.08	8000	52	39	150.00
Y410A	12.40-18.00	0.10	4500	91	419	210.00
K410A	18.00-26.50	0.10	4000	53	425	230.00
U410A	26.50-39.50	0.10	3000	96	381	250.00
C402A	5.85- 8.20	0.03	8000	50	344	1275.00
X402A	8.20-12.40	0.03	8000	52	39	1275.00

* With transmission coupling probe.

DELIVERY FROM STOCK

FXR M.M. TYPES (Micrometer Reading)

Model No.	Frequency Range KMc	Price (F.O.B. Woodside)
Q410X	33-50	$325.00
M410X	50-75	300.00
E410X	60-90	500.00
F412A	90-140	750.00
G412A	140-220	750.00

DELIVERY FROM STOCK

FXR, Inc.
Design • Development • Manufacture
25-26 50th STREET
WOODSIDE 77, N. Y.
RA. 1-9000
TWX: NY 43745

PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQUIPMENT

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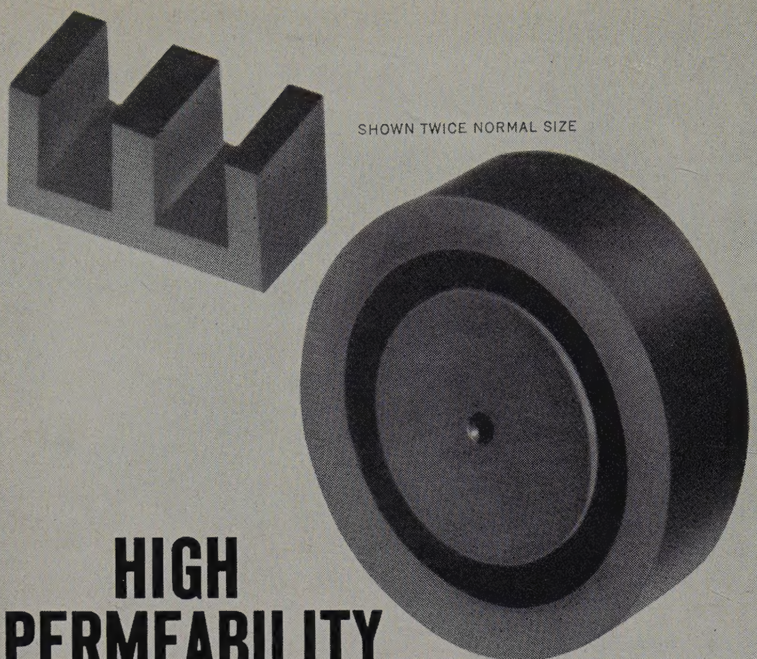

HIGH PERMEABILITY FERRITE

Kearfott's MN-30 ferrite is a highly machinable, high-permeability ferrite for use in magnetic cores. Its low losses and high saturation magnetization permit efficient application at frequencies up to 500 kc, while eddy current losses are minimal due to the material's high resistivity. Custom shapes and sizes available with dimensional tolerances within ± .001, density ranges from 4.9 to 5.0 gm/cm³. High quality and uniformity are assured through special compounding techniques, automatic control of firing, and rigid quality control.

TYPICAL CHARACTERISTICS

Initial Permeability at 21°C and 5 kc	3000 Min.
Maximum Permeability, measured at 2000 gauss	6000
Flux density at 7 oersteds, using Rowland Ring Test Circuit and Fluxmeter	4600 gauss
Flux Excursion for 1 oersted	3500 gauss
Retentivity (B_r)	1300 gauss
Coercivity (H_c)	0.13 oersteds
Loss Factor $1/\mu Q$ at 50 kc	7.5×10^{-6}
Loss Factor $1/\mu Q$ at 500 kc	30×10^{-6}
Temperature Coefficients of initial permeability (% per °C):	
From —30°C to +125°C	0.28
Curie Temperature	over 180°C
D. C. Restivity	250 ohm-cm

(All magnetic properties are held within a tolerance of ±15%)

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

LETTER TO THE EDITOR

Editor, *the microwave journal*
1330 Beacon Street
Brookline 46, Massachusetts

Dear Sir:

I read your editorial "The Perils of Sub-Contract Work" (January) and appreciate your comments very much.

Every small microwave business is sorely tried by the problem of the recovery of development costs conditional upon receiving production orders. As you point out, the competitor who has no development costs to recover enjoys an advantage in the production bidding.

As you also point out, "the prime contractor indicates a lack of funds for development". When this occurs, the small microwave businessman decides to take the calculated risk to ingratiate himself with the prime contractor.

A possible method of recovering some of this development cost could be effected when the contracting officer grants an increase in development funds on a project, part of that increase to be passed on to the sub-contractors working on the job.

Too often, the prime contractor is able to get an increased allocation, but under the present system he could not pass any of the increased allotment to work previously let on a fixed contract. The sub-contractor suffers on development work and model work unnecessarily when this claim of "lack of development funds" becomes habitual with buyers and may have outlived its necessity.

The art would benefit if more people were encouraged to use their specialized talents in development work for specific requirements of the industry and if this were made properly rewarding.

I want to commend you for your excellent editorial and sincerely hope that it will bear fruit in beginning a campaign for the assistance of a segment of an industry which makes a more valuable contribution to society than the rock and roll composer that you mention.

Respectfully yours,

Irving M. Gross
President
Portchester Instrument Corp.
Port Chester, N. Y.

—*mwj*—

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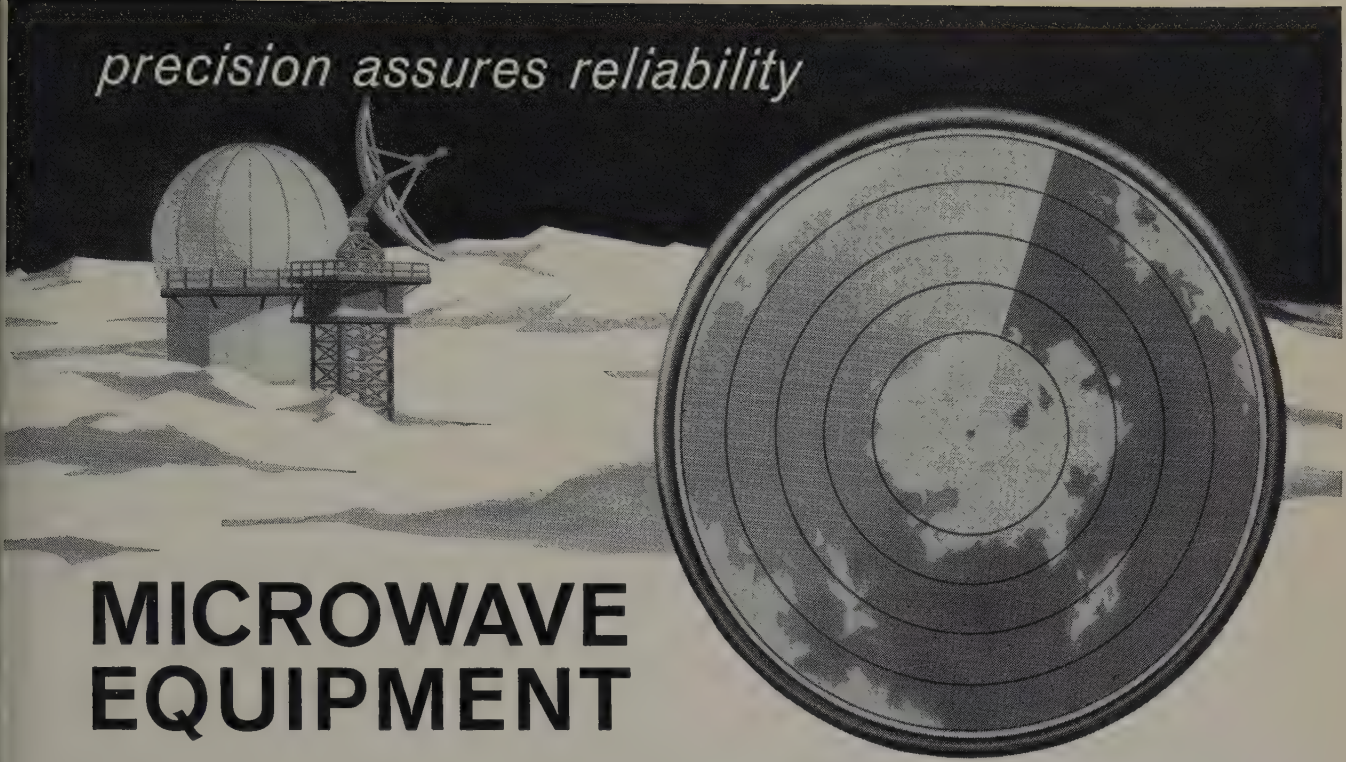
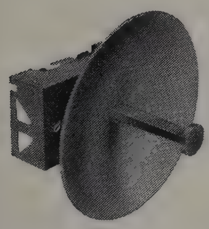
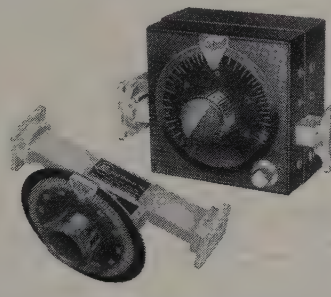
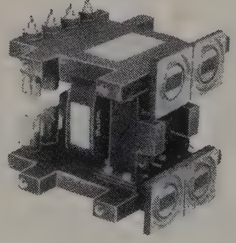


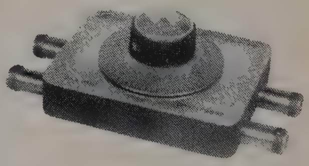
MICROWAVE EQUIPMENT

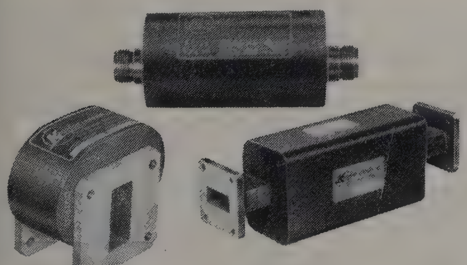
Reliable performance in all environments is assured with Kearfott precision microwave equipment and components. Available from the experienced Kearfott organization are: Complete systems design and development, engineering, high production capacity utilizing the newest in equipment and dip-brazing techniques, modern check-out and test facilities. A Kearfott Engineer can help you with the most exacting microwave design needs.

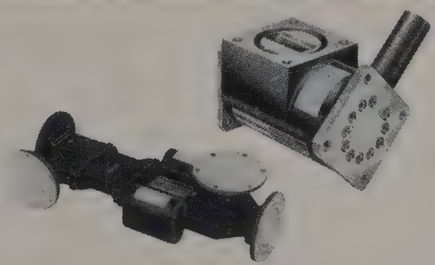

ANTENNAS AND R.F. SYSTEMS

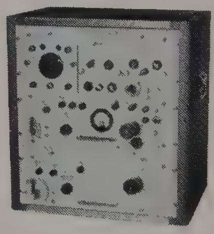

VARIABLE PRECISION ATTENUATORS


MICROWAVE SUBSYSTEMS


VARIABLE DIRECTIONAL COUPLER


FERRITE ISOLATORS

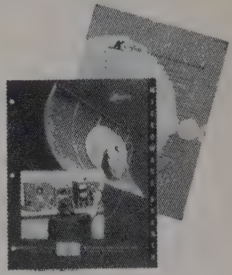

FERRITE DUPLEXERS


RADAR SIMULATORS AND TEST EQUIPMENT

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Technical bulletins on all Kearfott products are available on request.



SALES OFFICES
Seattle, Wash. Van Nuys, Calif. La Jolla, Calif. Dallas, Texas Dayton, Ohio Little Falls, N. J.
Los Angeles, Calif. Palo Alto, Calif. Phoenix, Ariz. La Grange, Ill. Orlando, Fla. Washington, D. C.

Industry News

MOTOROLA APPOINTS SABEL TO DIVISION STAFF

Motorola's Military Electronics Division, Scottsdale, Ariz., has announced the appointment of Arnold R. Sabel to its senior technical staff.

In his new position, Sabel will contribute to the development of long range technical plans for space and airborne electronics systems, according to Dr. H. William Welch, Jr., director of research and development for the Division.

With Motorola for the past 10 years, Sabel's diversified engineering experience encompasses systems design and development, engineering management and tactical operations analysis and other systems studies.

—*m w j*—

POTTER NAMED PRESIDENT OF DCA UNIT

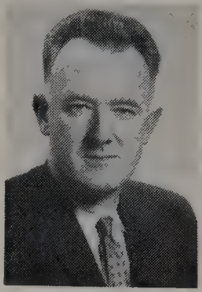
Election of Horace R. Potter as President of the Reeves-Hoffman Division of Dynamics Corporation of America has been announced by Raymond F. Kelley, DCA President and Board Chairman. Mr. Potter, who joined the Company in 1951, had been Vice President and General Manager of the Reeves-Hoffman Division since 1959.

Mr. Potter is a member of the Institute of Radio Engineers, National Security Industrial Association, American Institute of Management and the Society for the Advancement of Management.

—*m w j*—

HEARD WILL DIRECT TECHNICAL ACTIVITIES

Harry G. Heard, formerly Chief Engineer of Levinthal Electronic Products, has been appointed Vice President of Radiation at Stanford, Palo Alto, Cal.



Mr. Heard joined Levinthal in 1959 and has been responsible for the design of super-power microwave systems, high-voltage fault-diverters and multi-megawatt modulators.

Mr. Heard will direct the technical activities of the newly-formed R-F Systems Division.

—*m w j*—

MELABS APPOINTS SMITH BUSINESS MANAGER

Don A. Smith has been appointed business manager of Melabs, microwave engineering firm.

Mr. Smith, who joined Melabs in February, 1959, was appointed secretary-treasurer of the company last year and was recently elected to the firm's Board of Directors. He previously was associated with Firstamerica Corp., San Francisco.

He was graduated from San Jose State College in 1951 and received a master's degree in Business Administration from Stanford University in 1955.

—*m w j*—

(*Continued on page 14*)

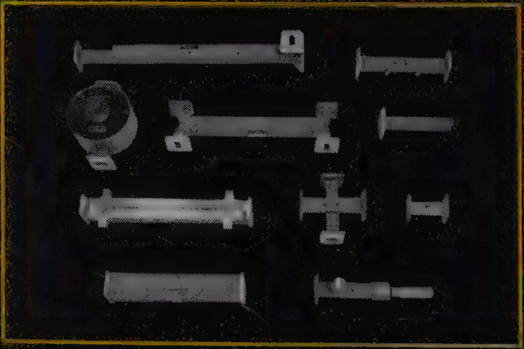
OTHER
outstanding Creations
from
MICROWAVE DYNAMICS

HIGH POWER
Pulse Modulators and Power Supplies

Unusual capabilities in the modulator and power supply fields have enabled Microwave Dynamics to develop and produce such significant instruments as this Magnetron Power Supply and Modulator, which features a 10 µsec "crowbar" and built-in current overload protection.

Output Specifications:

Voltage	Current	Ripple
0-7 kvdc 0-500 vdc 0-50 vac 0-10 vac	0-2.5 amps 0-500 ma 0-5 amps 0-50 amps	0.1% rms 1% rms
"crowbar" circuit: 10 µsec		

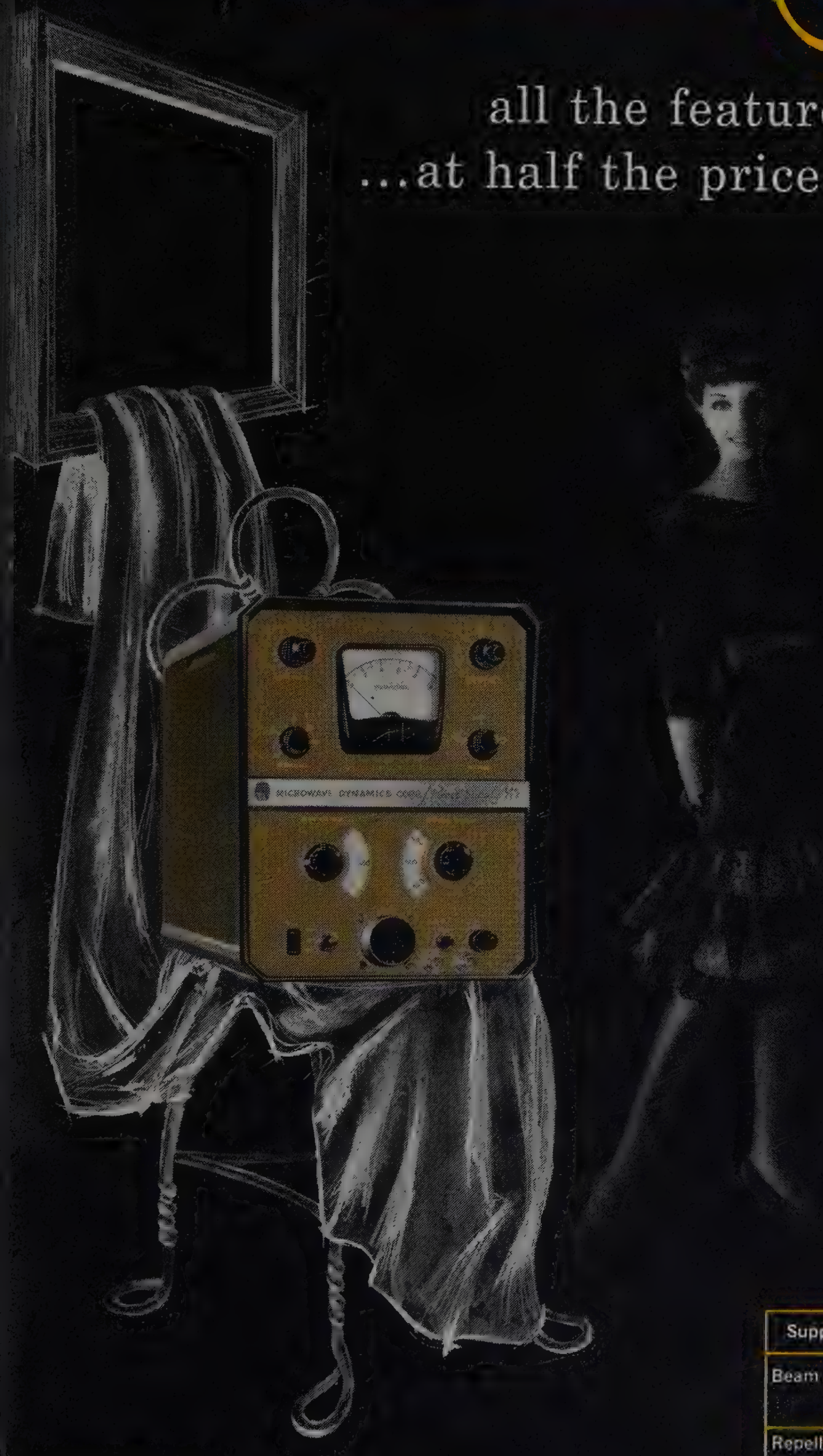


A complete line of WR75 (10-15 kMc/s) Waveguide Components available from stock.

A Symbol of Reliability in the Microwave Field
MICROWAV
PLAINVIEW INDUSTRI

an outstanding Creation...

all the features you'd expect to find ...at half the price you'd expect to pay


MICROWAVE DYNAMICS CORP.

Balenciaga Original
Courtesy of Macy's New York.

Uncompromising in their adherence to standards which they themselves have set, Microwave Dynamics' engineers have designed and produced an exceptionally-well regulated, highly stable Klystron Power Supply . . . only one of its kind to feature an adjustable DC filament supply, overload protection, a protective diode for limiting repeller current and continuously variable repeller and beam voltages. Another in the expanding line of microwave instruments specifically designed to meet the exacting demands of the microwave field, the Model 515 is a power supply which you know will match the maximum performance requirements of low voltage klystron tubes. The price tag reads only $750 . . . but it carries the unmistakable symbol of reliability which assures low-noise, low-ripple features found only in the most costly high voltage, wide range equipment.

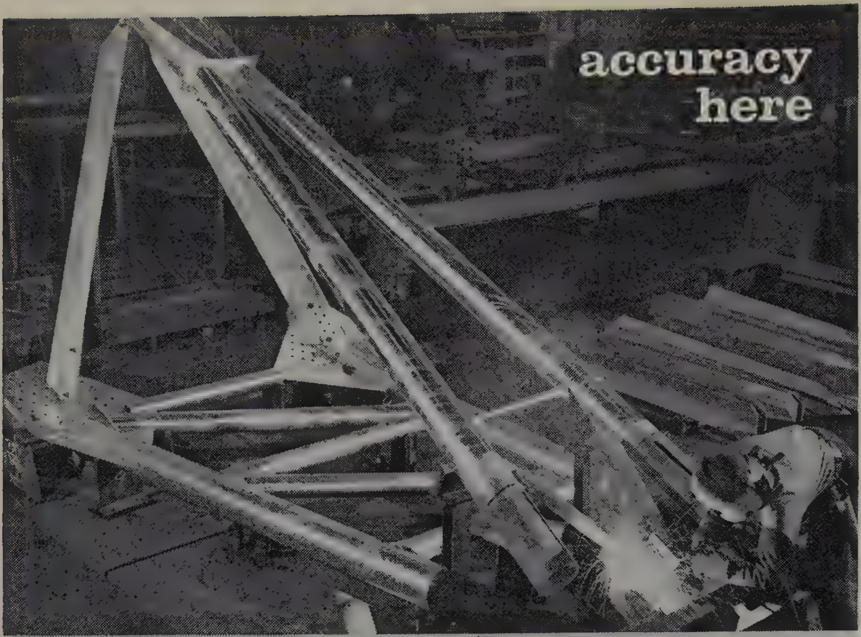
Supply	Voltage	Regulation	Ripple
Beam	Continuously Variable 0-800 vdc 0-100 ma	<0.01% Change for ±10% Line Change	<1 mv rms
Repeller	Continuously Variable 20-1000 vdc 5 ma at max. voltage	<0.01% Change for ±10% Line Change	<0.5 mv rms
Filament	6.3/12.6 vdc 0-2 amps	—	—

Internal Repeller Modulation (0-200 v); Sawtooth: 40-400 c/s, Square Wave (clamped) 200-2000 c/s; Phaseable Line Frequency Sine Wave.

NAMICS CORPORATION a subsidiary of Talley Industries, Inc.

, PLAINVIEW, LONG ISLAND, N. Y. *OVerbrook 1-6811*

Complete information available on request



means
accuracy
here

■ The high degree of accuracy required in antennas and radio telescopes demands the finest precision manufacture. For example, assembling massive tetrahedrons like these to within thousandths of an inch requires a "master craftsman" attitude and years of training and experience. ■ Blaw-Knox men have this skill and experience—backed by the finest facilities. ■ Having these facilities and talents available, Blaw-Knox engineers design all types of antennas with maximum efficiency at minimum weight. All designs are determinate. Nothing is left to trial and error. ■ Blaw-Knox has designed and built most of the large antennas now in service . . . fabricates in steel, special alloys, and aluminum . . . designs to fit your needs or builds to your specifications. Complete research, engineering, testing and fabricating facilities are at your disposal. A letter or phone call will get immediate attention. Blaw-Knox Company, Pittsburgh 38, Pennsylvania.

BLAW-KNOX
ANTENNAS

BLAW-KNOX

Blaw-Knox designs and manufactures for America's growth industries: METALS: Rolling Mills • Steel Processing Lines • Rolls • Castings • Open Hearth Specialties • PROCESSING: Process Design, Engineering and Plant Construction Services • Process Equipment and Pressure Piping • CONSTRUCTION: Concrete and Bituminous Paving Machines • Concrete Batching Plants and Forms Gratings • AEROSPACE: Fixed and Steerable Antennas • Radio Telescopes Towers and Special Structures • POWER: Power Plant Specialties and Valves

Circle Reader Service Card 8

Industry News

(*Continued from page 12*)

CONFERENCE DUE IN 1962

The 1962 Conference on Standards an Electronic Measurements will be held August 14, 15, and 16, at the Boulder Col. Laboratories of the National Burea of Standards.

This is the third in a series of bienni conferences being sponsored by the Radi Standards Laboratory of the National Bu eau of Standards, the Professional Grou on Instrumentation of the Institute o Radio Engineers, and the Instrumentatio Division of the American Institute o Electrical Engineers. Previous conferenc (1958 and 1960) each attracted more tha 800 participants from industry, universit and government laboratories.

The technical program will cover th entire useful frequency spectrum, from direct current through microwaves, with emphasis upon the more fundamental as pects of standards and measurements. I will include considerations of the mos urgent current problems and also the ex pected needs of the future.

Further information may be obtaine from: Dr. John M. Richardson, Chie Radio Standards Laboratory, Nationa Bureau of Standards, Boulder, Col.

—*mwj*—

WIENER APPOINTED CHIEF VALU ENGINEER

Appointment of Sol Wiener as Chie Value Engineer was recently announce by Mr. Paul H Odessey, Executi Vice-President Polarad Electronic Long Island Cit N. Y. In this ne capacity, Mr. Wi ner will assum major responsibili for Polarad's co improvement, com ponent reliabilit and standardizati programs under the control of Mr. Stanl Seifer, Director of Quality Assurance.

Mr. Wiener joined Polarad in 1950 a Project Engineer and was later appoint Manager of the Commercial Producti Engineering Department.

—*mwj*—

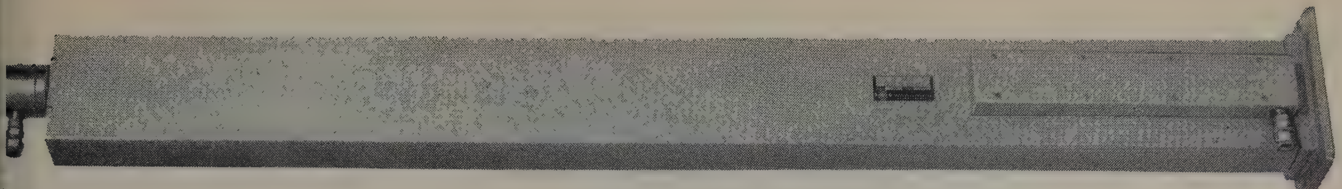
LITTON AND ELLIOTT PLAN BRITISH COMPANY

Negotiations have been concluded f the formation of a British company the microwave tube field by Litton Indu tries, Inc., San Carlos, Cal., and Ellio Automation of London, England.

Announcement of the plan to fo Elliott-Litton, Ltd., was made by Charl B. Thornton, president and chairman the board of Litton, and Leon Bag managing director of Elliott.

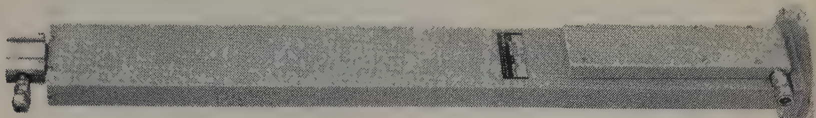
Final arrangements are subject to a

(*Continued on page 16*)



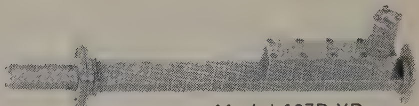
Model 187B-SL

COMPLETE LINE OF VERSATILE, EFFICIENT WAVEGUIDE WATER LOADS

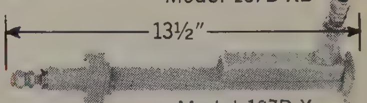


Model 187B-S

Model 187B-C



Model 187B-XB



Model 187B-X

for SL, S, C, XB and X Frequency Bands

Five models covering five bands
Three models useful in pressurized systems
VSWR less than 1.10
Can handle 2-20 kw average power
Low rf radiation
Calibration heaters in all models

These Sierra high-power waveguide terminations are extremely useful as dummy loads in calorimetric power-measuring systems. They feature rugged construction, with rigid plastic water tube mounted in waveguide section, diagonally oriented for impedance matching. Chokes and shielding minimize rf leakage, and a heater element built into each model permits rapid, accurate calibration of a calorimetric power-measurement system against a low-frequency standard.

CHECK ALL THESE SPECIFIED ADVANTAGES!

Model Number:	187B-SL	187B-S	187B-C	187B-XB	187B-X
Frequency Range:	1.7 to 2.6 kmc	2.6 to 4.0 kmc	5.8 to 8.2 kmc	7.0 to 10.0 kmc	8.2 to 12.4 kmc
VSWR:	< 1.10 to 2.4 kmc < 1.15 to 2.6 kmc	less than 1.10	less than 1.10	less than 1.10	less than 1.10
Power Average: (Unpressurized)	20 kw	10 kw	5 kw	3 kw	2 kw
Peak Power:	2 megawatts	1 megawatt	500 kw	250 kw	150 kw
Max. Air Pressure:	*	*	45 psig	45 psig	45 psig
Waveguide:	RG-105/U	RG-75/U	RG-50/U	RG-51/U	RG-52/U
Connector:	UG-437A/U	UG-584/U	UG-344/U	UG-51/U	UG-39/U
Recommended Water Flow:	2 gpm for 10 kw	2 gpm for 10 kw	1 gpm for 5 kw	0.6 gpm for 3 kw	0.4 gpm for 2 kw
Pressure Drop at Rated Flow:	10 psi	10 psi	10 psi	10 psi	10 psi
Max. Water Pressure:	80 psig	80 psig	80 psig	80 psig	80 psig
Water Temperature:	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C	0 to 70° C
Water Capacity:	18.5 cu. in.	3.5 cu. in.	0.85 cu. in.	0.42 cu. in.	0.20 cu. in.
Water Renewal at Rated Flow:	Once per 2.5 sec.	2 times per sec.	4.3 times per sec.	5.3 times per sec.	7.4 times per sec.
Heater Resistance:	4.5 ohms	9 ohms	14 ohms	20 ohms	20 ohms
Heater Rating:	10 kw at 2 gpm	5 kw at 1 gpm	3 kw at 1 gpm	1 kw at 0.6 gpm	1 kw at 0.4 gpm
Length:	50 in.	32 in.	20 in.	17.25 in.	13.5 in.
Price:	$600.00	$500.00	$425.00	$400.00	$375.00

*Not pressurized

Data and prices subject to change without notice. Prices f.o.b. factory

For complete details, see your Sierra Representative or write direct.

NEW! Sierra also offers its Model 186 Series Coaxial Water Loads, covering dc to 4 kmc.

sierra

SIERRA ELECTRONIC CORPORATION
A Division of Philco Corporation
6807C BOHANNON DRIVE • DAvenport 6-2060 • MENLO PARK, CALIFORNIA, U. S. A.
Sales representatives in all principal areas
Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver
Export: Frazar & Hansen, Ltd., San Francisco, Los Angeles

6807

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MICROWAVE MANAGER

This ferrite phase differential circulator is an Airtron device for managing microwaves in X-band. It was specifically designed to meet the requirements of very high power systems operating at 2 megawatts of peak power and 1500 watts of average power over a frequency band of 8500 to 9600 Mc/s while pressurized at 3 atmospheres. Used as a duplexer, with its fourth arm terminated in a dummy load, this water cooled unit provides 20 db isolation between channels. Others are available for Ka through S bands in both aluminum and brass constructions.

With modifications, these ferrite circulators have been used as diplexers, discriminators, isolators, and switches. Let us work with you, or quote, on the specific configuration for *your* application. Or, write for additional information.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N.J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N.J.

Circle Reader Service Card 10

Industry News

(*Continued from page 14*)

propriate governmental approvals which are currently being sought.

The new firm will handle production, distribution and sales of electron tubes developed by Litton's Electron Tube Division of San Carlos, Cal., and microwave tube operations of Elliott Brothers (London) Ltd., a member of the Elliott-Automation Group.

— m w j —

FIELD RECEIVES BEST PRESENTATION AWARD

Dr. Lester M. Field, manager of Hughes Aircraft Co.'s microwave tube division, Los Angeles, Cal., has received an award for the best presentation at a session of the recent Winter Convention on Military Electronics.

Dr. Field's talk reviewed the technological advances which have made it possible for the Hughes division to develop wideband, high power traveling wave tubes capable of producing several kilowatts continuous wave and up to several hundred kilowatts pulsed. These tubes are used in ground and satellite communications. He also discussed light weight periodically focused amplifier tubes for satellites having output powers of one watt.

— m w j —

SWEDEN SIGNS DEFENSE ORDER WITH MARCONI

The Royal Swedish Air Board has placed a further contract to the value of over 25,000,000 Swedish Crowns (£1,700,000) with Marconi's Wireless Telegraph Co. Ltd., Essex, England, for the supply of secret electronic equipment for their air defense system. This follows orders placed in 1959.

The twin problems which face any defense organization are those of range of operation and warning time. The Swedish Air Force is powerfully equipped with fast fighters and surface-to-air missiles, but to use these effectively means must be found of collating relevant information and arriving at swift decisions.

This is being done largely by electronic means, although the final decision as to when and how to act is in the hands of senior control executives.

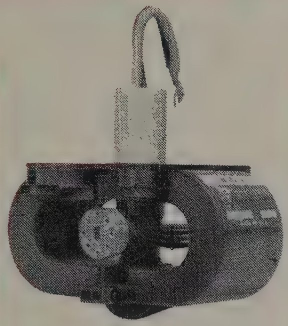
At the center of the Marconi system is a very high speed computer which solves a large number of interception problems simultaneously and enables the defense weapons — fighters, guided missiles and other defensive devices — to be brought into action at precisely the right instant. Black and white television and color projection together with automatic information-dissemination techniques also play a vital part in the overall system. Approximately 500,000 transistors and diodes and 15,000 valves are incorporated in the equipment.

— m w j —

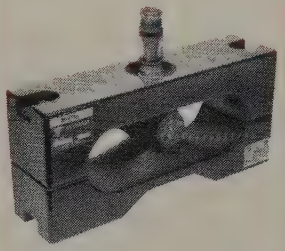
(*Continued on page 28*)

MICROWAVE DEVICE NEWS from SYLVANIA

120KW



20 KW
to
120 KW
peak power output



with Sylvania Ka Band Magnetrons

20KW

Sylvania Ka Band Magnetrons offer a remarkable range of powers, fill virtually all your Ka band requirements. They include extremely compact types with exceptional power-to-weight ratios. All are fixed-frequency types for pulsed operation, utilize stabilized magnets, and exhibit outstanding reliability and longevity.

SYLVANIA-5789, first commercially available U. S. type for Ka band, uses 22-vane "rising sun" anode, and improved dispenser-type cathode. With hermetically sealed input and pressurized output, it is highly adaptable to high altitude operation.

SYLVANIA-6799 features 120KW peak power output and is a proven high-power millimeter wave source. It is available for use with longer pulses and higher duty cycles at slightly reduced power.

SYLVANIA M-4155A, *ruggedized* version of the 5789, features compact size and weight of only 9 lbs., improved heat dissipation and excellent stability. It utilizes a special cone-shaped cathode support and "building block" mounting arrangement for added mechanical strength. M-4155A possesses both long- and short-pulse capabilities.

SYLVANIA XM-4064, *ruggedized* magnetron, offers exceptional stability under severe environmental conditions. Only 9 lbs. in weight, it provides peak power output of 70KW for a remarkably good power-to-weight ratio.

SYLVANIA XM-4158, *ruggedized* magnetron, provides 120KW peak power output. Weight is only 27 lbs. It uses E type magnets for a uniform, flat surface configuration that can be used as a structural part of the chassis. XM-4158 is compatible with either long- or short-pulse operation.

SYLVANIA XM-4218, *ruggedized* tube, provides a power-to-weight ratio of 8:1 making it especially suited for portable, field-type radar. It uses metal-to-ceramic seals, ceramic cathode capsule, cantilever cathode support. The tube withstands 50g shock, 10g vibration tests. XM-4218 provides a lower pushing factor than tubes of comparable performance.

SYLVANIA XM-4206 is a *ruggedized,* compact tube with encapsulated cathode. Only 10.5 lbs., it provides 40KW peak power output.

SYLVANIA Ka BAND MAGNETRONS

	Frequency (KMC)	Peak Power Output (KW)	Max. Duty Cycle	Max. Pulse Width (μsec)
5789	34.512 35.208	40	.0006	1.0
6799	34.512 35.208	120	.0005	1.0
M-4155A	34.512 35.208	40	.0006	1.0
XM-4064	34.512 35.208	70	.0008	1.0
XM-4158	34.512 35.208	120	.0006	1.0
XM-4218	34.512 35.207	32	.0006	0.4
XM-4206	34.7 35.0	40	.0006	1.1

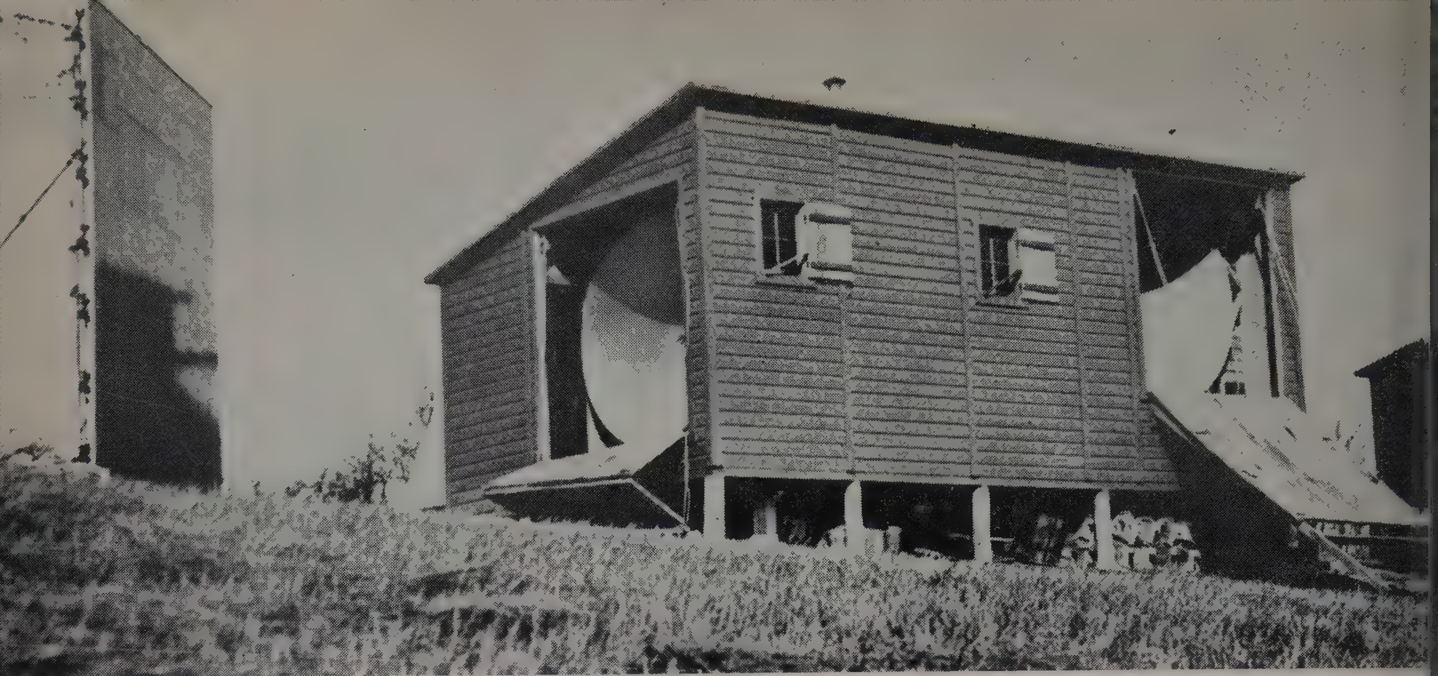
Investigate the design advantages of Sylvania Ka band magnetrons *and* associated Ka band TR tubes. Contact your Sylvania Sales Engineer for complete information. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-D, 1100 Main St., Buffalo 9, N. Y.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM



Califon, N. J. terminal at time of 1930 American line-of-sight microwave communication experiments, (1700 Mc/s).

MICROWAVE PEOPLE

ANDRE G. CLAVIER

Scientific Advisor

ITT FEDERAL LABORATORIES NUTLEY, NEW JERSEY

30 Years Ago

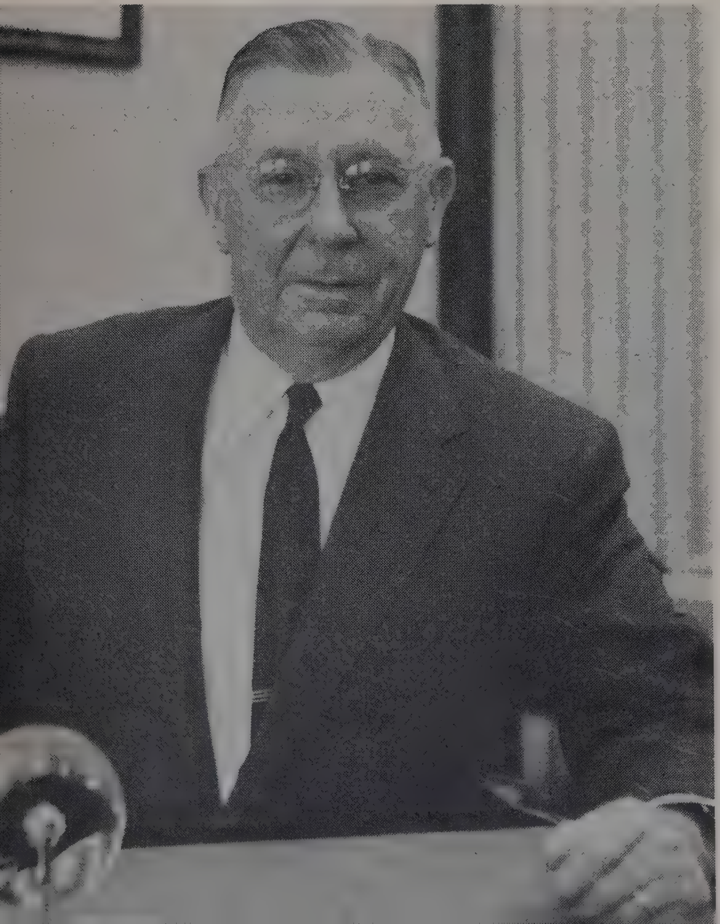
A nostalgic reunion took place recently between a distinguished scientist and a wooden shack that 30 years ago was the scene of experiments in microwave techniques that began a new era in electronics.

That meeting, in a sense, highlighted the honor-studded career of Andre G. Clavier, scientific advisor to the president of ITT Federal Laboratories, Nutley, New Jersey and pioneer in the early microwave research that can be directly linked to the development of present-day radar, network television, line-of-sight and over-the-horizon radio and television.

Today that wooden shack is a seldom-used hay barn that stands on the Van Pelt farm, a few miles east of Califon, New Jersey. In 1930, however, it was the northern terminus of a 17½ mile line-of-sight radio link that, but for a shift in planning by International Telephone and Telegraph Corporation, would have been the site of the world's first public demonstration of microwave communications.

That demonstration did take place, of course, but some 3,000 miles away between Dover, England and Calais, France.

(*Continued on page 23*)



Andre G. Clavier, Scientific Advisor to the President, ITT Federal Laboratories, Nutley, N. J., a division of International Telephone and Telegraph Corporation.

Above, Mr. Clavier is shown emerging from receiving cabin aboard vessel off coast of Toulon, where in 1941 he conducted important research on microwave scatter propagation.

Right, Mr. Clavier and his associates are shown at time of 1930 U.S. microwave experiments, standing on roof of ITT's since vacated Newark, N.J. facility. Left to right are Charles Mabie, Dr. William J. Cahill, Mr. Clavier and Surrius R. Montcalm.

Below, scene at Calais, France during ITT historic 1931 demonstration. Among those present were, third from right, Dr. E. M. Deloraine, new president of ITT's Laboratoire Central de Télécommunications, Paris; fourth from left, front row, the late Professor Henri Abraham, of the Sorbonne; fifth from left, front row, Professor Camille Gutton, member of the French Academy of Sciences; and Dr. Phillip Le Corbeiller, now professor of applied physics at Harvard University, sixth from left, front row.

DEFENSE DE TOUCHER
DANGER DE MORT

FROM **Monsanto** FLUIDESIGN SERVICE:

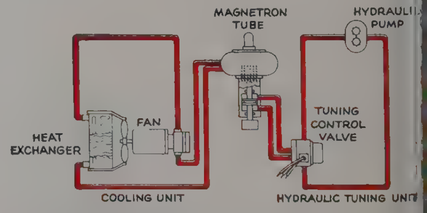
NEW DIELECTRIC-
PINPOINTS TEMPERATURE
VITAL ELECTRONIC
COOLANOL® 35
STAYS IN LIQUID PHASE
500° F. OPERATING

Temp., °F.	Viscosity, cs. COOLANOL 35	COOLANOL 45
420	0.84	1.25
410	0.87	1.30
400	0.90	1.35
0	60	125
-10	80	170
-20	110	260
-30	160	380
-40	240	650
-50	400	1030
-60	700	1800
-65	934	2600
-80	2780	—

Mission: national survival.

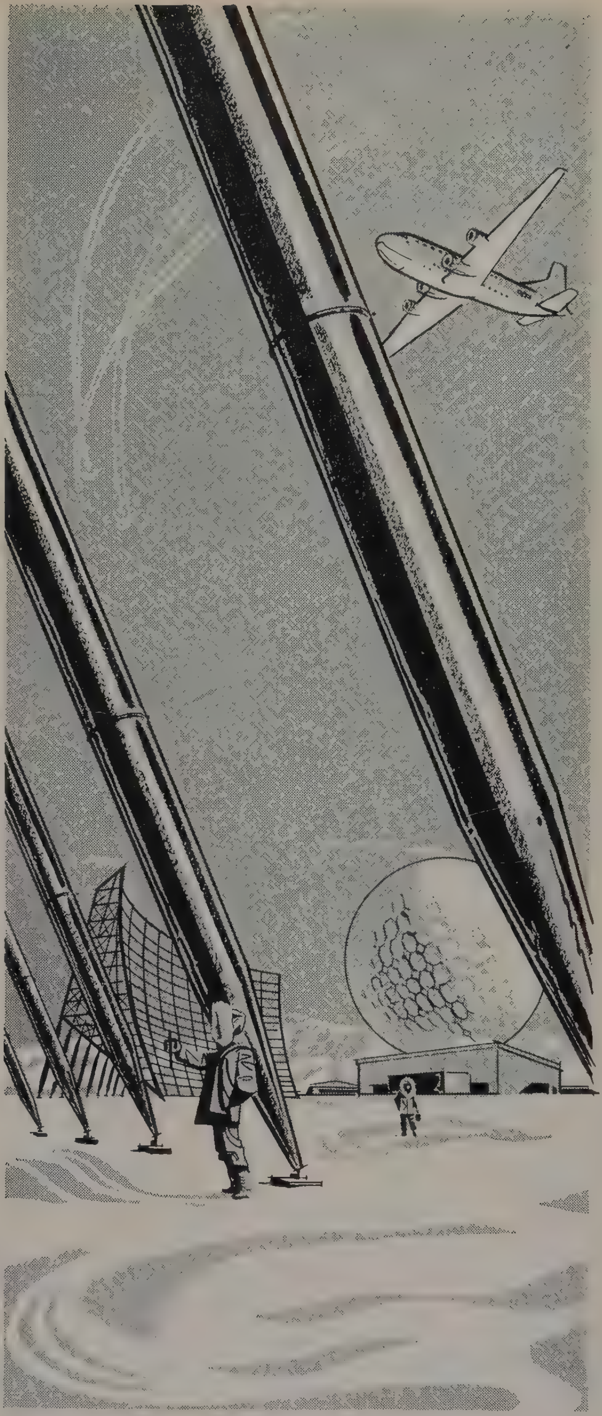
Assignment: synthesize a liquid dielectric-coolant to meet stringent new military requirements—for critical heat control of compact electronic components that must *function flawlessly*—in supersonic aircraft, tactical missiles, tropical ground support complexes, and radar installations along the Arctic shores.

Achievement: COOLANOL 35—a "chemically tailored" fluid combining excellent low-temperature viscosity—thermal stability—high dielectric strength—and good heat transferenc in environments ranging from *a sizzlin, 420°F. to an icy -80°F.* (so cold lead pencils won't write and ordinary rubbe tires crack like eggshells)!



Here's how COOLANOL cools, lubricates, and hydraulically actuates a magnetron and tuner

COOLANT
CONTROL OF
EQUIPMENT!



THROUGH A
RANGE!

ET THE COMPLETE FACTS ON NEW COOLANOL 35. MAIL THE HANDY COUPON TODAY.

SOME TYPICAL PROPERTIES OF COOLANOL 35

our Point (ASTM D97)	<-120°F.
pecific Gravity, 25/25°C.	0.889
ielectric Strength, 5°C. (ASTM D877)	47KV
hermal Conductivity, 25°C. (cal./sec. cm^2 °C. cm)	29.1×10^{-5}

MONSANTO CHEMICAL COMPANY
FluiDesign Service, Dept. 4436 M
St. Louis 66, Missouri

Please send my copy of Technical Bulletin AV-6
on new COOLANOL 35

Name____________________Title____________

Company______________________________

Street________________________________

City______________Zone_______State_________

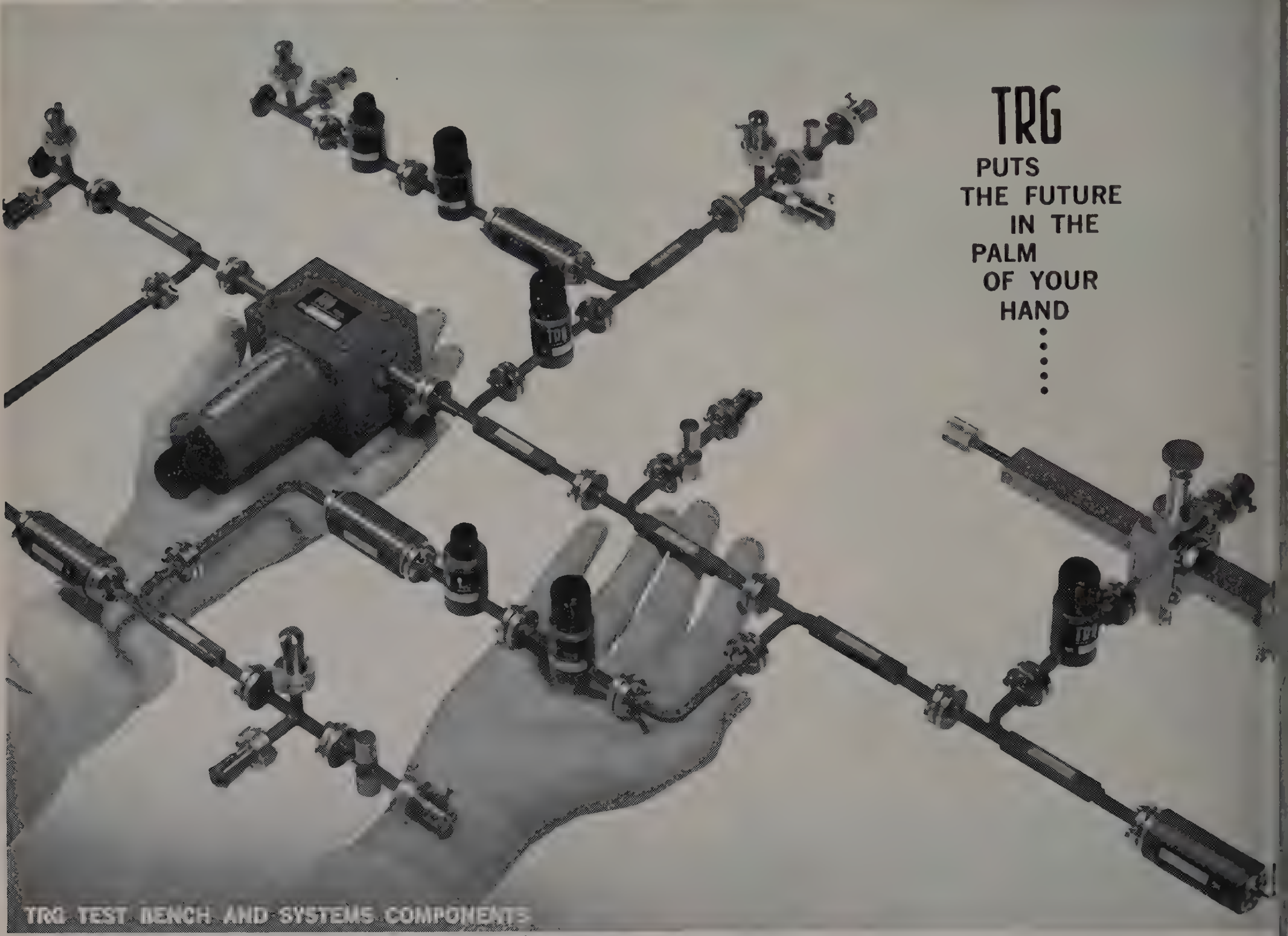
Circle Reader Service Card 11

A complete line of millimeter wave TEST BENCH and SYSTEMS COMPONENTS . . . from stock! As far as TRG is concerned, the future is here and now when it comes to test bench and systems components. We offer a complete line, off-the-shelf. These same stock items have permitted us to work on advanced 'custom' curcuits in such areas as millimeter spectroscopy, plasma diagnostics, and many other sophisticated areas where extremely stable sources of millimeter power are required. The circuit pictured is a good example. TRG was responsible for design and fabrication of the entire circuit. Yet it is made up — 100% — of standard TRG stock components. You'll find them listed below. For a more complete listing of TRG components, please write. Whatever your problem — a component or complete systems development . . . TRG has more of everything it takes, including experience, to put the answers right in the palm of your hand.

TRG

TECHNICAL RESEARCH GROUP 9 Union Square, Somerville, Mass.

Experimental microwave measurement circuit for r/d of low noise millimeter amplifiers — built entirely from stock components. Circuit provides pump and signal power at amplifier input as well as heterodyning signal for detecting amplifier output. A single klystron, phase-locked to harmonic of an ultra-stable reference frequency through TRG six harmonic mixer, generates all signals. Short-term V Band signal stability: 5 parts in 10^8.



TRG TEST BENCH AND SYSTEMS COMPONENTS

FREQUENCY RANGE — KMC	A-band 26.5–40	V-band 50–75	E-band 60–90	F-band 90–140	TYPICAL PERFORMANCE FOR A, V and E BANDS	REMARKS
Isolator	A110	V110	E110	F110*	VSWR 1.25 — Loss .7db — Isolation 17db min., 25 db at center	Bandwidth: 6% A-band, 3% V and E-ban Low power Faraday rotation type isolator
Precision Attenuator	A510	V510	E510	F510*	0 — 50db — Insertion loss 1db (not included in calibration) — Error .1db or 2% of reading, whichever is greate	
Uncalibrated Attenuator	A520	V520	E520	F520	VSWR 1.2 — Attenuation .2db to 25db	Resistance card inserted in waveguide
Phase Shifter	A525	V525	E525	F525	VSWR 1.15 max. — Loss 0.9db — Phase Shift 0–180° min.	Uncalibrated phase shifter. Operates over full waveguide band
Frequency Meter		V550	E550	F550	.2% Accuracy	Covers full waveguide band
Directional Coupler (10, 20db)	A560	V560	E560	F560	VSWR 1.15 — Directivity 20db — 10% Band	
Tunable Detector Mount	A570	V570	E570	F570	Tunes over waveguide band	Micrometer driven short circuit-IN53 crystal or cartridge bolometer
E/H Tuner	A620	V620	E620	F620	Tunes over waveguide band	Micrometer driven non-contacting short circuits
Harmonic Mixer	A730	V730	E730	F730	Built to customer requirements. Can be supplied for 1st to 6th harmonic mixing	Mixer diode built directly into junction of crossed waveguides. Microdot I.F. connector supplied

*Under development

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CLAVIER

(*Continued from page 18*)

This little-known and hitherto unpublished vignette in the life of Andre G. Clavier came to light during a recent interview for an article in the Company's employee publication.

Microwave Challenge

In 1930, Mr. Clavier, then associated with International Telephone and Telegraph's Laboratoire Central de Telecommunications in Paris, was sent to this country to direct his experiments toward one objective: to challenge the then accepted principle that wire or cable circuits should be used in preference to radio whenever physically possible.

With this goal in mind Mr. Clavier and his ITT associates chose two Jersey stations: the Califon site and the since-destroyed south terminus that was half-way between Montgomery and Zion on the north slope of the Neshanic Mountain.

Into the frame buildings went prototype equipment so advanced in principle and design that the installations closely resembled modern terminals operating today. Mr. Clavier points out, for instance, that the 10-foot dish antennas used—one of the electronic "firsts" in this new field—eventually became a standard for microwave transmission.

After six months of intensive effort, the equipment was installed and testing got underway. With plans being formulated for what was to have been the historic demonstration, a change in ITT policy transferred the engineer back to France, and the American experiments were discontinued.

Victory at Sea

The rest is communications history. Dover and Calais were chosen as the location of the ITT experimental stations, and in 1931, the gray waters of the English Channel, rather than the rolling green hills of New Jersey, became the scene of the demonstration. Events of that day proved that microwave transmission indeed could offer the world of communication economy, quality, dependability, and flexibility of an order never before thought possible.

Henri Busignies, ITT vice president, general technical director, congratulates Andre G. Clavier during 1959 dinner honoring Mr. Clavier's 30 years with the ITT System.

Mr. Clavier, center, discusses klystron used in Toulon scatter propagation tests conducted in 1941. With him are left, Gen. Frederic Hellot, then president of ITT's Le Matériel Téléphonique, Paris and Jean Roussel, then LMT general manager.

In recalling those long-ago days and his associates, Charles Mabie, Dr. William J. Cahill, and Surrius R. Montcalm, Mr. Clavier often reflects on the destiny that chose Europe rather than the United States for a great moment in microwave communication.

This man's reflective nature and inquisitive mind have always kept him in the forefront of microwave research and development. His successful demonstration across the Channel led to Mr. Clavier being placed in charge of the developmental work for the French-English Lympne-St. Inglevert microwave radiotelephone link inaugurated commercially by ITT in 1934.

Contributions

In pre World War II France he was studying and made important contributions to the use of waveguides and millimeter wave communications long before any practical use was seen for these techniques. In 1941 Mr. Clavier was again ahead of the electronic world in conducting over-the-horizon experiments in the Mediterranean. His work here clearly brought to light the essential propagation characteristics of 10-centimeter waves and furnished basic information for the practical utilization of these waves in line-of-sight as well as 0/H links.

But, impressive as these facts are that measure Clavier the engineer-scientist, granted 38 U.S. patents and with 302 taken out in foreign countries for his original work, they tell us little of Clavier the man. He was born in Cambrai, France in 1894 and studied at the college there, at the universities of Lille and Paris, and received his electrical engineering degree from Ecole Superieure d' Electricite, Paris in 1920. He has held key executive and

(*Continued on page 24*)

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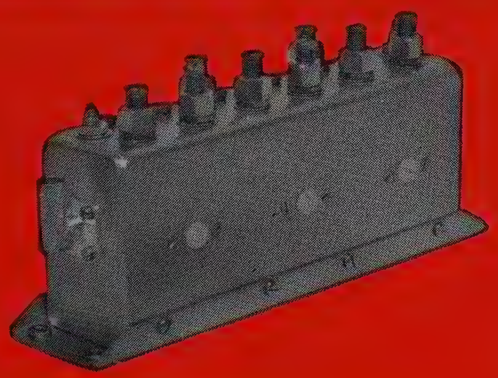

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SPECIFICATIONS

	Model HFF	Model HFF-T
Center frequency	100 kcs—1000 mcs, preset	200-4000 mcs, preset
Bandwidth	5%-25% of f_0, preset	1%-15% of f_0, preset
Impedance	50 ohms.	50 ohms
V.S.W.R.	≦1.2 in pass band, consistent with peak to valley ratio	
Insertion loss	≦1 db	≦1 db
Peak to valley ratio	≦.5 db	≦.5 db
Selectivity	Defined by number of resonant elements. Doublets to sextuplets or greater are available	
Power rating	25 watts	100 watts
Connectors	BNC or Type N	BNC or Type N

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CLAVIER

(*Continued from page 23*)

engineering positions with the ITT System for over 30 years.

In discussing his life's work in electronics, the scientist considers how he was able to contribute original work to his field. "I deliberately looked for the unknown, and then, being aware of the mystery that surrounded large areas of the radio spectrum, I applied myself to solving the riddles," he says.

His originality is not confined to the laboratory, either. A large part of his success has been in getting his associates to work together to produce new concepts in engineering. "There must be enthusiasm," Mr. Clavier is fond of saying, "because there will be no real work without it. Likewise, the happiness brought about by recognition of work well done, should also be a key factor in the management of men," he says.

Along this same line, and based on his vast experience with many engineering and scientific associates, Mr. Clavier feels that this country, although making strides in the right direction, has yet to understand the exceptional man and to provide the suitable atmosphere to take the best advantage of his creativity.

Research Heritage

Apparently the scientist has been successful in passing on to his two children his great love of research. His daughter, Mrs. Christiane Wilkinson, holds one of the few PhD's in nuclear physics granted to a woman by Cambridge University. Her husband is also an eminent physicist and teaches at Oxford. Mr. Clavier's son, Philippe is an electrical engineer doing research with Ford's Aeroneutronic Division. Mr. Clavier and his wife Alberte, whom he married in 1919 when they were students at the Sorbonne, have seven grandchildren.

For relaxation these days Mr. Clavier likes to listen to his favorite classical music, and when he finds time, visit the art museums. But don't be misled. He is still the active engineer and inquisitive scientist. As a Fellow of both the IRE and the AIEE, and as president of the American section of the Societe des Ingenieurs Civils de France, he keeps abreast of the current thinking and developments. And, naturally, there is his latest research project — the application of electronics to medicine. Again, his talent for management is seeking ways for the physician and engineer to meet to discuss as a team the problems to be solved, and his creative spirit is once again considering the unknown. All is as it should be with Andre G. Clavier.

PAPERS

We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

Papers can be addressed to:
"the microwave journal," 1330 Beacon St., Brookline, Mass.

— *m w j* —

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When submitting a change of address, please complete the subscription card inside the back cover of the magazine. Include the address at which you have been receiving *the microwave journal*, and allow one month for the change to become effective.

PROGRESS IN MICROWAVES

ow to Minimize RF Interference . . .

GENERAL ELECTRIC HARMONIC FILTERS COVER NTIRE MICROWAVE SPECTRUM

To alleviate interference prob- ms caused by harmonics generated high-power transmitters, General lectric offers a broad line of rmonic-absorption filters. Design pability extends from UHF to -band.

ROVIDE EFFECTIVE CONTROL

Rapidly increasing use of the icrowave spectrum by military d civilian systems makes it im- rative to establish positive con- ols on high-power transmitters. eneral Electric harmonic filters ovide an effective means of con- ol by minimizing harmonic and urious signals to the levels indi- ted in current military specifica- ons, such as MIL-R-27055(USAF).

CREASE POWER-HANDLING CAPACITY

General Electric harmonic filters rovide other important benefits. By absorbing unwanted harmonic power, a properly designed filter can often substantially increase the fundamental power-handling capability of the wave-guide transmission line on the load side of the filter. Moreover, elimination of wave-guide arcing and protection of the output tube are provided by the filter.

DESIGN CAPABILITY

General Electric now has five years' experience in the research, development, and design of harmonic filters. Capability gained through this experience enables General Electric to design and manufacture harmonic filters for any application on a relatively short time cycle. The table below describes presently available types. These can be modified to fit particular requirements.

SPECIFICATIONS AND AVAILABILITY

TYPE	PASS BAND (KMC)	PEAK POWER (MW)	WAVEGUIDE SIZE	DELIVERY (IN DAYS)
MPF-400	0.4-0.45 (UHF)	5	WR-2100	90
MPF-800	0.75-0.98 (UHF)	0.1*	WR-975	90
MPF-1001	1.2-1.4 (L)	10	WR-650	90
MPF-2501	2.6-3.1 (S)	5	WR-284	60
MPF-2502	2.6-3.6 (S)	5	WR-284	60
MPF-4000	5.0-6.0 (C)	1	WR-187	60

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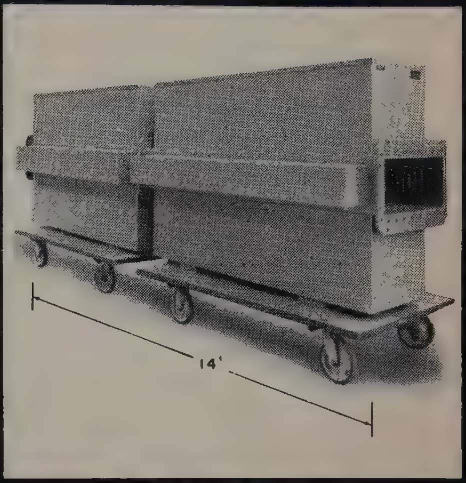
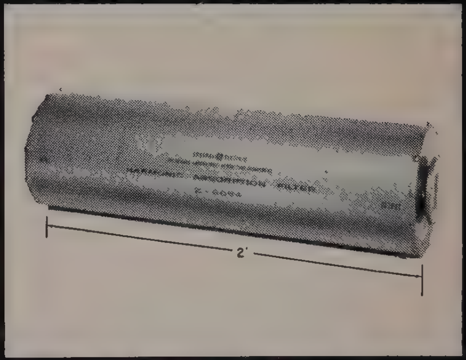
FILTER DESIGNS AVAILABLE FOR APPLICATIONS FROM UHF TO K-BAND



MPF-400 (UHF)



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- Harmonic Filters

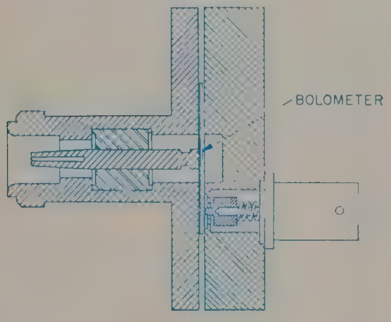
PRD *previews/reviews/design notes*

Bolometers, Barretters, and Thermistors

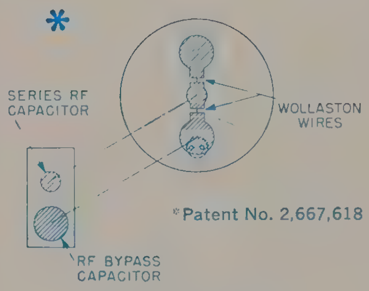
We have often been asked, "What is the difference between a bolometer, a barretter, and a thermistor?" At PRD the following is generally accepted: *Bolometer* is a general term which describes a temperature-sensitive element whose resistance changes as it dissipates microwave power. Bolometers include (a) thin short lengths of Wollaston wire, (b) evaporated metallic film, (c) small beads of semiconductors. The wire and film types are called "bolometers" or "barretters" and have a positive temperature coefficient. The semiconductor is called a "thermistor" and has a negative temperature coefficient.

Power Measurement Equipment

The bolometer, plus appropriate mount, provides us with an accurate, dependable means of measuring microwave power. In itself, of course, the bolometer is a temperature-sensitive resistor, and gives no indicator reading. The most commonly used instrument for direct reading of microwave power is the self-balancing bridge. The PRD 650-B Universal Power Bridge can accommodate bolometers, barretters, or thermistors and reads power directly to 100 milliwatts.

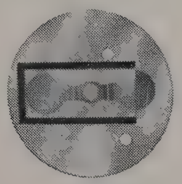


BOLOMETER MOUNT



*Patent No. 2,667,618

BOLOMETER ELEMENT



PRD 631-C

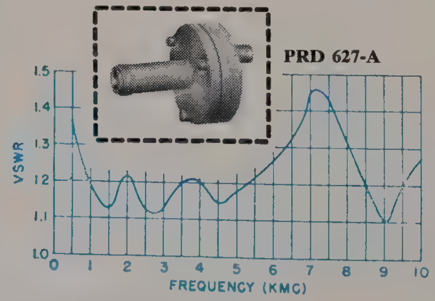
Design Details

The drawing above is the PRD 627-A Broadband Coaxial Bolometer and Thermistor Mount which houses the PRD 631-C (wire type), PRD 631-D (film type), and PRD 631-G (thermistor). The two general types of bolometers manufactured by PRD are Wollaston wire and evaporated metallic film applied to thin mica discs. The PRD 631-G Thermistor uses two semiconductor bead elements and has excellent stability characteristics.

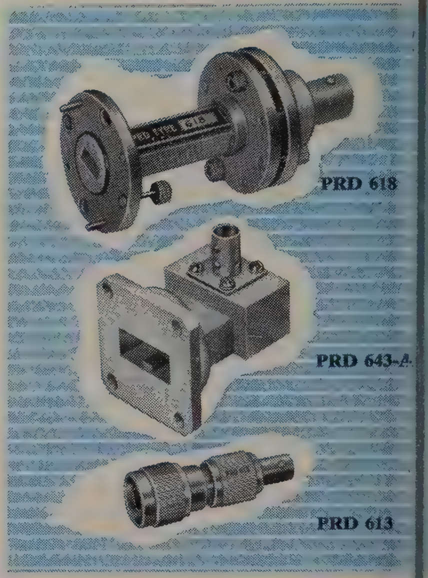
Each bolometer has a nominal operating resistance of 200 ohms when biased. For low power (1 mw max.), the PRD 631-C uses short lengths of Wollaston wire which when deplated cannot be seen by the naked eye but must be delicately constructed under powerful microscopes. The metallic film units (PRD 631-D) are high power devices and can dissipate up to 100 mw.

Mounts

PRD bolometer mounts, such as the PRD 627-A, require no tuning, operate over a frequency range of 500 to 10,000 megacycles/sec, and are designed to insure high efficiency. The mount provides a low VSWR over the entire band and allows for easy replacement of bolometer elements without retuning. A typical VSWR curve is shown.



PRD produces a variety of mounts and bolometers. These include coaxia waveguide, tunable, and broadban Shown are, from top to bottom, Waveguide Bolometer Mount (PR 618) which operates from 26.5 to KMC/S, a Waveguide Thermist Mount (PRD 643-A) for 8.2 to 12 KMC/S, and a Coaxial Crystal ar Bolometer Mount (PRD 613) for 1 12 KMC/S.



Precision in Producti

PRD offers as standard catalog iter some 34 different mounts and sev types of bolometers and thermisto Our assembly line turns out sever hundred bolometers alone in a wee all of which undergo rigorous stabil and humidity tests after constructio PRD also produces, of course, necessary associated equipment f power measurement. For more theor ical information, write for PRD Rep Vol. 1, No. 4, "Microwave Pow Measurements" or contact our App cations Engineering Department.

We have many interesting openings fo engineers...contact Mr. John R. Zabk

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". . . THE JAPANESE MICROWAVE EQUIPMENT INDUSTRY WILL LAG FAR BEHIND OUR OWN."

JAPAN: competitor or customer?

By J. VANCE HOLDAM, JR.

Because of its enormous strides in electronics and the resulting competition that its industry represents, Japan has become a major interest to the American electronics industry.

Early in 1960 I visited Japan on a selling trip and spent much time talking with technical personnel in both industry and government. My impressions are that, although the Japanese electronic industry is a major factor in competitive component markets, there are large areas of the electronics business where we can not only compete successfully for world markets but we can sell to the Japanese.

The Japanese have developed many of their own components, and have been licensed by American manufacturers, making for a sizable component manufacturing capability. I would like to cite some of the f.o.b. selling costs quoted by Japanese manufacturers for components of a quality comparable to that obtainable in the United States.

(1)	small ceramic trimmers	$42. per thousand
(2)	6J6 vacuum tubes	30¢ each
(3)	4 in. diameter permanent magnet speakers	66¢ each in lots of 50,000
(4)	miniature potentiometers	9¢ each in lots of 10,000
(5)	slide-type switches, double pole, double throw	4¢ each in lots of 100,000

Note that there is no inclusion here of any microwave component. This is not accidental as the data that is published refers to 1959 and the early part of 1960, and, at that time, there were no microwave components being exported from Japan in any quantity appreciable enough to get recognition.

In the case of microwave equipment manufacture, except for microwave links and small radars, it is not now in evidence in Japan, primarily due to the rather unsophisticated level of know-how, since the Japanese capability in these equipments stems from companies that have been performing IRAN work. This "inspect and repair as necessary" is much of the way Japanese industry has become familiar with the state-of-the-art of American radar equipment. Since this type of business does not support research and development and the engineering content of repair contracts is exceedingly low, the Japanese microwave equipment industry will lag far behind

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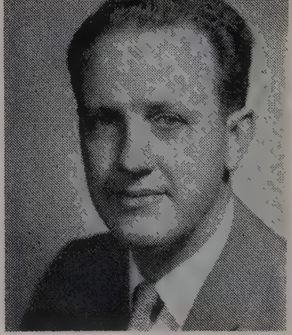
J. VANCE HOLDAM, JR., one of the three scientists who joined forces in 1946 to found LFE, is an alumnus of the Massachusetts Institute of Technology Radiation Laboratory where he was project engineer in charge of development and design engineering of World War II airborne fire control radars, and a scientific consultant on projects undertaken by USAAF Headquarters.

In 1957 Mr. Holdam was named vice president for operations at LFE. He supervised engineering, Manufacturing, Computer and Special Products Divisions, and formed LFE's Quality Control and Service Divisions. Appointed vice president for all LFE marketing activities in the summer of 1959, he reorganized that function and created the Advanced Development Division. His duties take him to Europe, South America and Asia.

Mr. Holdam received his BS in Physics from the University of Chattanooga, and his MS in Physics from the University of Michigan.



our own, and as a result, Japan becomes a prime market.

In dealing with Japan it is necessary to take into account several factors that are unique in its economy when considered in its relation to that of the United States. These are principally as follows:

(1) A great deal of business is done through trading houses which represent a substantial factor (one that does not exist in the United States) in their economy. Trading houses represent the selling agency as well as the buying agency in many cases, and in addition, often act as bankers. One result of this development is that manufacturing concerns do not have particularly strong sales organizations and depend upon trading houses to do their selling. Similarly, they do not have particularly strong buying organizations, because they also depend upon the trading houses to do the purchasing.

(2) Another very important factor is the degree of governmental control on industry in Japan in an effort to reduce competition. This seems to be highly unusual to an American in view of the fact that we are used to competition. The effect of reduction of competition in Japan is not to make prices and profits inordinately high. The Japanese approach is that the economy is such that it cannot stand murderous competition and the Japanese trust their own instincts not to under-bid each other so far as to be disastrous. In any case, there seems to be a major effort on the part of the government, by indirect control of industry, to prevent serious competition.

(3) One of the striking characteristics of technical personnel in Japan is their willingness to be immobile. Engineers and professional people in general, once hired by a company, expect to work for that company for the rest of their working life. There is no large exchange of engineering and professional talent, even management talent from company to company, comparable with the enormous flow of personnel in the United States. This characteristic makes the economy appear secretive and may be one of the reasons why the Japanese government seems to stick its fingers into the various phases of business. Government agencies know what's going on in various businesses.

(4) The Japanese are making a major effort to live down their pre-World War II reputation in the United States for manufacture of shoddy goods. One of the principal approaches to this was the formation of industry associations to control quality. The first major export of Japan to the United States, following World War II was optical goods, especially 35 millimeter cameras. The American that got the original franchise to distribute Japanese cameras in the United States convinced them that they had to overcome the reputation of shoddy goods and convinced the Japanese optical industry to form an association to watch quality. This has had a marked effect within the post-war foreign trade economy of Japan. It is now recognized as an important factor in the rapid growth of their export market.

(5) In general, Japanese industry is geared to mass production in the sense that there is a very large ratio of direct labor to engineering personnel. The result is striking and is an important factor for consideration by Americans. The range of American products will always be much larger than the range of products in Japan simply because the engineering content of American products is larger, so a larger number of models can be built. It is also important in considering that Americans can compete now and for several decades to come, in view of the fact that the production rate of technical personnel is very low in Japan, on any product that has a high engineering content.

I would summarize my impression of the Japanese microwave industry and its effects on us as follows:

The areas affected by Japanese competition are consumer products and industrial products and there is little of a microwave industry in either one of these broad categories. Except for microwave communication, an area in which Japan excels, and small radar equipments, the microwave business is dominated by military IRAN operations. Since this type of business does not support R&D and engineering content is low, the Japanese microwave industry is not now, and—providing we continue to progress—may never be an appreciable factor of competition in microwave equipment.

Industry News

(Continued from page 16)

HAUTZIK JOINS QUANTATRON

Robert Hautzik has joined the Microwave Laboratories of Quantatron, Inc., Santa Monica, Cal., as Manager of Microwave Engineering.

In making the announcement, Leonard Pincus, Vice-President of Quantatron and Director of the firm's Microwave Laboratories, said that Mr. Hautzik's responsibilities will include microwave engineering and supervision of design and drafting, prototype production, and engineering services associated with the Quantatron line of functional microwave devices, particle accelerators, pulse modulators, magnet supplies, and advanced high-power microwave equipment.

Mr. Hautzik's experience in radar and microwave engineering covers the past fifteen years. He was Chief Engineer of Airtron, Inc., for several years. Prior to this, he was associated with a number of governmental agencies, including the Armed Services Electro Standards Agency.

— mwj —

SHAPIRO ELECTED PRESIDENT AT AEROSPACE

At a recent meeting of the Board of Directors, Mr. L. Dennis Shapiro was elected President of Aerospace Research, Inc., Cambridge, Mass. The company is primarily involved in radio propagation, communications, solid state instrumentation and ionospheric physics.

Mr. Shapiro, who is also director of the research activities at ARI was formerly Chief, Space Research Section, Pickard & Burns, Inc., Needham, Mass. He has been involved in such programs as the International Geophysical Year, Hardtack, Argus, Firefly, and has conducted research in nuclear effects and over-the-horizon missile detection.

— mwj —

DON WHITE ESTABLISHES BETHESDA OFFICES

Don White Associates, a technical consultant firm specializing in electronic systems analysis, has established private consulting offices at 7306 Honeywell Lane, Bethesda, Md. with clients in U. S. Government agencies and private industry. Headed by Donald R. J. White, it offers quality technical guidance and staff support on problems of radio-frequency interference prediction and control, mathematical modeling and evaluation of electronic weapons systems, operations analysis of communication-electronic systems,

(*Continued on page 30*)

NEW POWER
through C and X band
C BAND
8,000
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NEW PPM METAL-CERAMIC TRAVELING WAVE TUBES

Climaxing ITT's long history of pioneering in the traveling wave tube field are these new PPM types covering C and X bands and distinguished by the highest power output over the greatest bandwidths thus far available. The X-band TWT Type X-354 is rated at 5 watts CW from 8 to 12 kilomegacycles; the C-band TWT Type X-370 is rated at 10 watts CW from 4 to 8 kilomegacycles. Type X-368 serves as a driver for the X-354. As in other ITT traveling wave tubes, construction is exclusively metal and ceramic.

Power output and frequency coverage of this caliber result in a new standard of performance. For ECM requirements, frequency diversity radar or any other broadband microwave application, ITT has a complete line of S-band, C-band and X-band TWTs rated from .050 to 10 watts CW and to 1 kilowatt pulse output. ITT traveling wave tubes are available for immediate delivery and are backed by the world-wide resources and facilities of the ITT System.

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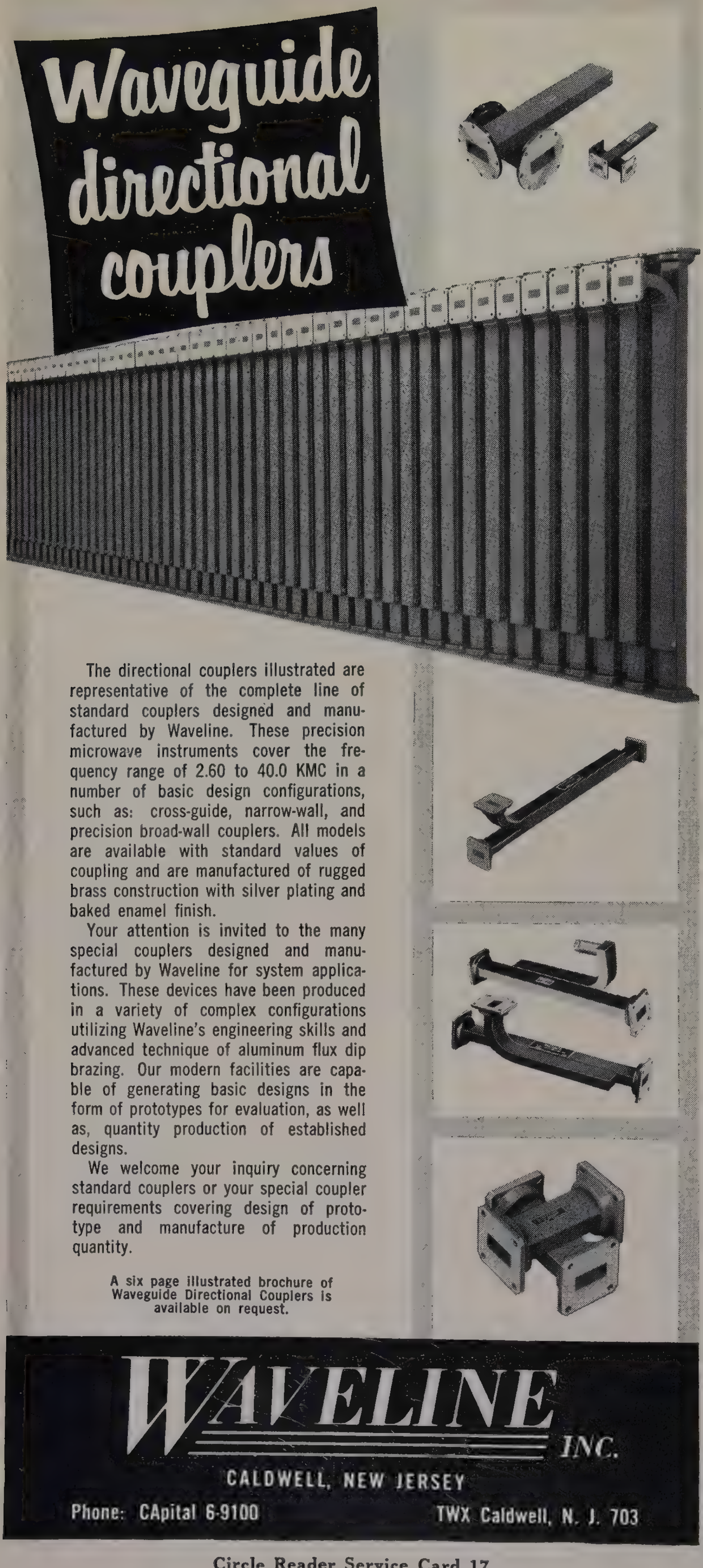

The directional couplers illustrated are representative of the complete line of standard couplers designed and manufactured by Waveline. These precision microwave instruments cover the frequency range of 2.60 to 40.0 KMC in a number of basic design configurations, such as: cross-guide, narrow-wall, and precision broad-wall couplers. All models are available with standard values of coupling and are manufactured of rugged brass construction with silver plating and baked enamel finish.

Your attention is invited to the many special couplers designed and manufactured by Waveline for system applications. These devices have been produced in a variety of complex configurations utilizing Waveline's engineering skills and advanced technique of aluminum flux dip brazing. Our modern facilities are capable of generating basic designs in the form of prototypes for evaluation, as well as, quantity production of established designs.

We welcome your inquiry concerning standard couplers or your special coupler requirements covering design of prototype and manufacture of production quantity.

A six page illustrated brochure of Waveguide Directional Couplers is available on request.

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Industry News

(*Continued from page 28*)

and electronic intelligence research programs.

Mr. White holds BSEE and MSEE degrees from the University of Maryland and has thirteen years of experience in directing electronic system design and evaluation programs.

He is a Registered Professional Engineer, a Senior Member of the IRE, Chairman of the Third National IRE Symposium on Radio-Frequency Interference, and a member of Tau Beta Pi.

— *m w j* —

MEETING ON HIGH PRECISION CONNECTORS TO BE HELD IN JUNE

A one-day meeting on High Precision Connectors will be held June 29, 1961, at the Boulder Laboratories of the National Bureau of Standards, Boulder, Col.

The objective of the meeting is to reduce those errors in precision measurements which are due to connector uncertainties in coaxial equipment at radio and microwave frequencies. It is expected that this can be achieved by agreement on design, size, tolerances, etc., of a minimum number of connectors which will be used by standardizing laboratories and incorporated in manufactured instruments capable of high precision.

The morning will be devoted to papers giving quantitive information on high precision connectors and the afternoon to a round table discussion on the same topic.

Papers and discussion are invited on such subjects as the influence of mechanical and electrical tolerances on the residual discontinuity of connectors, residual discontinuities in coaxial lines and cables, high precision coaxial lines, dielectric material for supports in connectors, support structures for connectors, power handling capacity, upper frequency limits of connectors, adapters for differing diameters and impedances, measurement methods and results, stability and wear properties of electrical metals, surface plating and maintenance, adapters to existing connectors, fabrication methods, leakage resistance, recommended sizes, characteristic impedance, frequency ranges, maximum VSWR, environmental performance, current and anticipated needs, and other topics which may aid agreement on an optimum coaxial connector for high precision work and national and international agreement.

Abstracts of papers should be submitted by May 1, 1961, to R. C. Powell, National Bureau of Standards, Boulder, Col.

— *m w j* —

HEWLETT-PACKARD FORMS NEW DIVISION

A new division for engineering and manufacturing oscilloscopes has been formed by the Hewlett-Packard Co., Palo Alto, Cal.

According to David Packard, president of the Palo Alto electronics firm, Cortlandt Van Rensselaer has been named

(*Continued on page 32*)

● Sperry garnet materials, products of Sperry research, are especially applicable for low frequency and high average power requirements under extreme temperature conditions. They are also superior, under certain conditions, in high peak power applications.

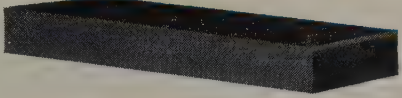
Important uses of Sperry garnet materials are in resonance isolators and in 3- and 4-port circulators for frequencies from 350 to 1500 mc and over broad temperature ranges.

Sperry garnets also are highly satisfactory in higher frequency devices—up to and including the X-band—where a maximum degree of temperature stability is necessary with high average power. Typical devices using certain of these materials operate from –65°C to +125°C, and at very high power levels.

Bars nominally measure 1½″ x 1″ x 6″.

Complete information relative to Sperry solid state materials furnished on request.

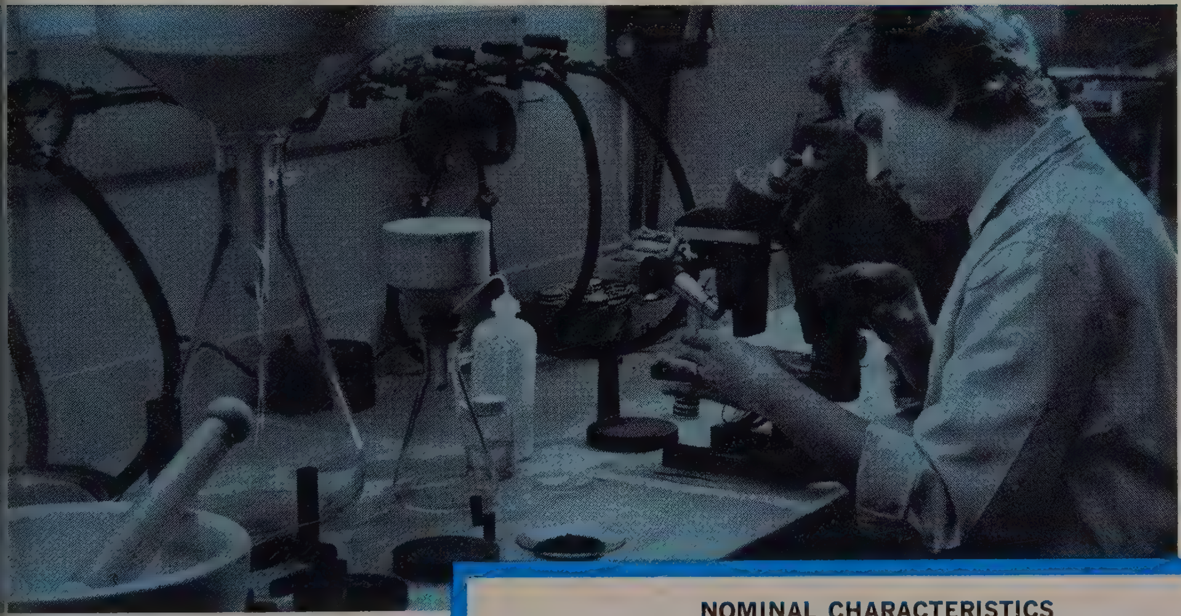
GARNET



materials

by

SPERRY



NOMINAL CHARACTERISTICS

MODEL	DENSITY (gm/cm3)	4 M_s (Gauss)			ΔH Oersteds at 9150 mc, 25°C	g-Factor
		–55°C	25°C	+125°C		
D80A1	5.05	1950	1750	1400	50	2.02
D80A2-1	5.25	1600	1475	1300	60	2.02
D80A2-2	5.40	1350	1250	1100	85	2.03
D80A2-3	5.60	950	1000	850	125	2.04
D80A2-4	5.75	700	750	750	225	2.06

Curie Temperature, T_C=280°C for all materials
Nominal Bar Size—½″ x 1″ x 6″

SPERRY

ERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORATION*

roline Instruments • Radar Test Sets • Systems Instrumentation • ***Solid State Devices and Materials*** *• Microwave Components and Antennas*

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THE LINCOLN LABORATORY
Massachusetts Institute of Technology

Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

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Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

Industry News

(*Continued from page 30*)

General Manager of the new division. M Van Rensselaer has been with Hewle Packard for 13 years, and was forme General Manager of Dymec, the syste division of Hewlett-Packard.

Mr. Van Rensselaer previously Sales Manager of Hewlett-Packard fo years. He was graduated from Stanf University in 1944 with a degree in e trical engineering, and in 1948 he recei his masters degree in Business Admi tration.

Mr. Robert A. Grimm, formerly ma facturing manager for Dymec, will succ Mr. Van Rensselaer as General Mana of that division.

—*mwj*—

IRE AWARDED GRANT FOR SUPPORT OF MEDICAL CONFEREN

The Institute of Radio Engineers, In has been awarded a grant of $10,000 the National Institutes of Health, and grant of $5,000 by the National Scie Foundation for the support of "The International Conference on Medi Electronics".

The 1961 International Conference Medical Electronics will be held on J 16-21, 1961, at the Waldorf Astoria Ho New York, N. Y. It follows three succe ful international conferences in Lond 1960, and Paris, 1958 and 1959. The 1 Conference will be a combined meet of the 4th International Conference Medical Electronics and the 14th Ann Conference on Electrical Techniques Medicine and Biology.

Associated with the Conference will an International Technical and Scien Exhibition displaying the latest techni and equipment in the medical electro field. The Conference Program will drawn from the areas common to engineering, medical, and biological fie

—*mwj*—

POLYTECHNIC NAMES VICE PRESIDENT

Polytechnic Institute of Brooklyn, N. has announced the appointment of Dr. than Marcuvitz as vice-president for search.

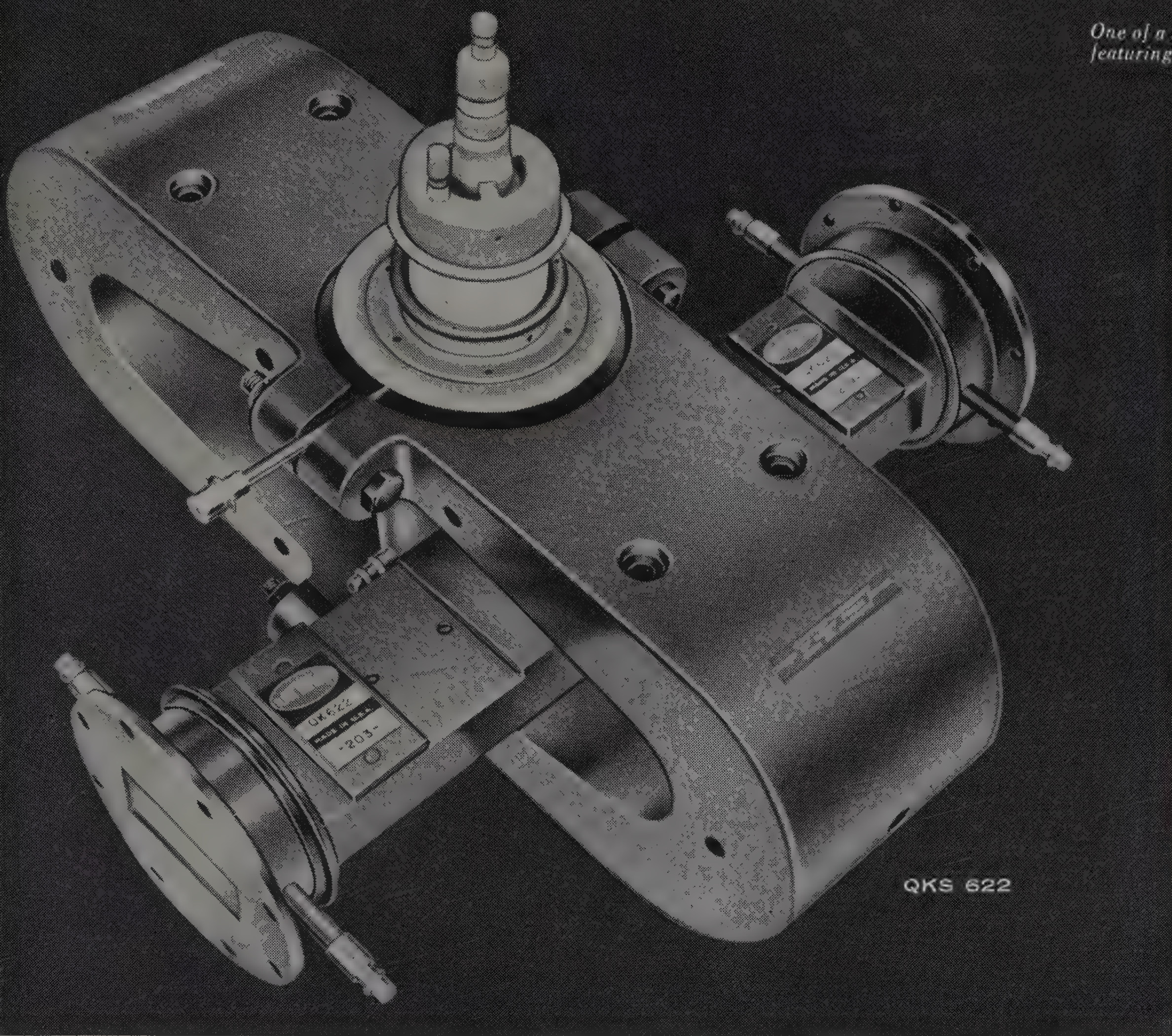
Dr. Marcuvitz has been director of P technic's Microwave Research Insti since 1957, as well as supervisor of electrophysics group since 1952. He also been for the last 12 years, electrop sics consultant to NYU's Institute of Ma ematical Sciences.

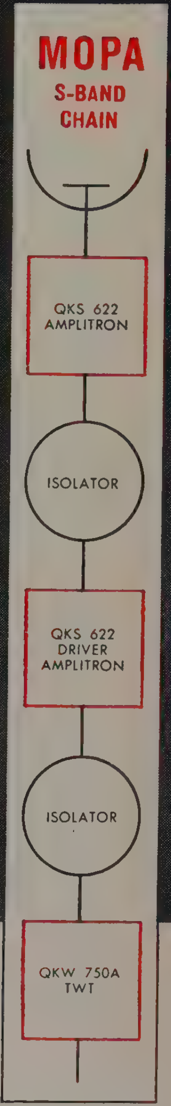
In his new position, the 48-year- electrical engineer will direct research jects totaling more than $3,500,000 in nual expenditures. Polytechnic research carried on in the fields of aerospace e neering, electrical engineering, chemis chemical engineering, physics, mechan engineering, civil engineering, metallu cal engineering and mathematics.

—*mwj*—

(*Continued on page 34*)

One of a series of advertisements featuring tubes for MOPA chains





Raytheon pulsed-type Amplitron* produces 3-megawatt S-band output at efficiencies of 75 to 80%

QKS 622 tubes are used as driver and final amplifier stages of broadband MOPA chain.

Raytheon Amplitrons are ideally suited for high power MOPA applications where extremely high efficiency is required. For example, a single QKS 622 Amplitron can produce up to 15 kw average and 3 megawatts peak power with 70 to 80% efficiency. Easily achieved parallel operation doubles these power outputs. Adequate drive power is supplied by the QKS 622 operating at lower levels.

This unusually compact 2,900 to 3,100 mc Amplitron has been operated at 30-microsecond pulse widths, and can be expected to perform satisfactorily at far greater widths. A companion tube, the QKS 783, covers 2,700 to 2,900 mc. Both tubes are specified for 1,000 hours.

QKS 622 GENERAL CHARACTERISTICS
(Typical Operation)

	DRIVER	FINAL AMPLIFIER
Pulse Duration	11 μsec	10 μsec
Duty Cycle	.0055	.0050
Peak Anode Voltage	48-52 kv	50-54 kv
Peak Anode Current	20 a	66 a
Peak Power Output	600 kw	3.0 Mw
RF Driver Peak Power	48 kw min	550 kw min
Cold Insertion Loss	0.5db	0.5 db
Heater Power	None Required	

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario. *Raytheon Trademark

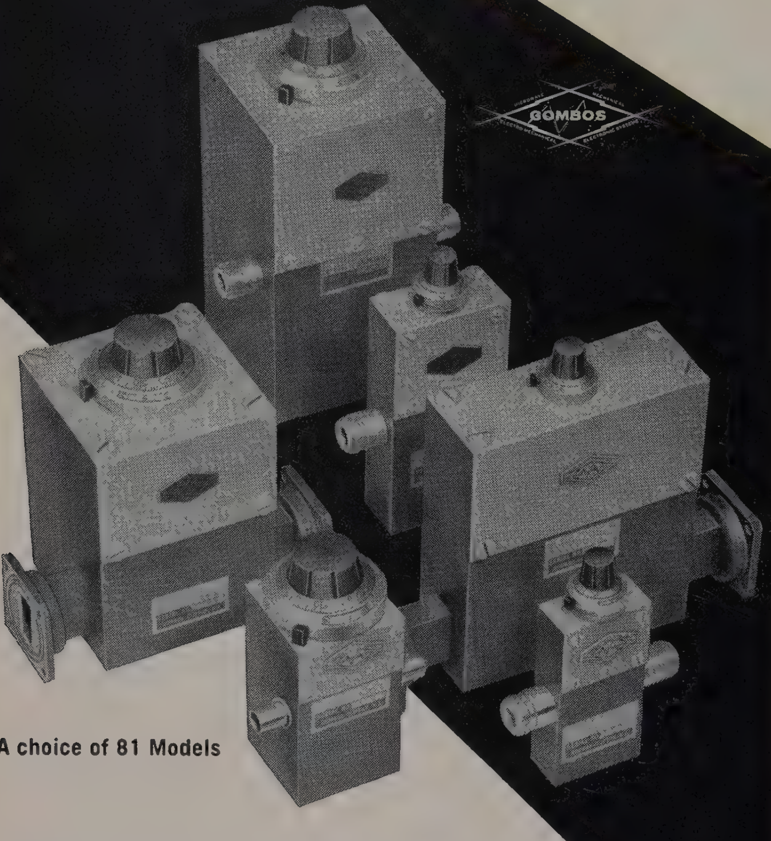
RAYTHEON COMPANY

RAYTHEON

MICROWAVE AND POWER TUBE DIVISION

BOSTON, MASS., BRowning 2-9600 • ENGLEWOOD CLIFFS, N. J., LOwell 7-4911 • BALTIMORE, MD., SOuthfield 1-0450 • CHICAGO, ILL., NAtional 5-4000 • DAYTON, OHIO, BAldwin 3-8128 • LOS ANGELES, CALIF., PLymouth 7-3151 • CANADA: Waterloo, Ont., SHerwood 5-6831

TUNABLE BAND PASS FILTERS



A choice of 81 Models

A COMPLETE LINE FROM 500MC TO 18,000MC

Single knob tuning

2, 3, & 4 Section models offer a selection of rejection characteristics

Low insertion loss (1.0 D.B. Max.)

Coaxial or waveguide application

The John Gombos Co., Inc. line of TUNABLE MICROWAVE BAND-PASS FILTERS is designed for laboratory application such as Image Filters, Noise Measurements, Harmonic Rejection, Frequency Selection and Spectrum Analysis. These filters are also designed for systems applications such as Video or Superheterodyne Preselection, Resonant Diplexing, Frequency Discrimination, Multiplexing and Band Elimination.

JOHN
GOMBOS
CO., INC.
WEBRO ROAD, CLIFTON, N. J.

WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

Industry News

(*Continued from page 32*)

NEREM 1961 CALLS FOR PAPERS

Technical papers describing significan original advancements — focused on research and development — are invited fo presentation at the 1961 Northeast Electronics Research and Engineering Meeting (NEREM) which will be held on November 14, 15, 16, 1961, in the Commonwealth Armory and the Somerset Hote Boston, Mass.

This year's meeting will feature marked departure in technical progra format, scope and size, as well as typ and number of exhibits. The program wil include many invited state-of-the-art tutorial sessions, discussion panels, as wel as contributed topical papers on new developments.

All IRE-Member registrants will receiv — at the conference — free-of-additiona charge, a copy of the NEREM Record: printed 200-page conference report wit 600-1000 word digests (supported b drawings and photographs) of every pape presented at the meeting.

A suggested, but not inclusive list o subject areas for NEREM 1961 is: Computers: Logic, Design, Application and Components; Microwaves: Components, Interaction Phenomena and Diagnostics; Systems: Surveillance, Communications, Radar, Guidance, Data-Handling Plasmas: Theory and Applications a Energy Converters, Millimeter-Wave Generators; Solid-State Devices: Semiconduc ing, Paramagnetic, Ferrimagnetic, Ferromagnetic, and Ferroelectric; Engineerin Management: Marketing, Productio Techniques, Reliability; Communicatio and Control: Theory and Applications.

Also suggested are: Antennas and Wav Propagation, Medical Electronics, Microelectronics and Electron Devices.

To permit the development of wel integrated technical sessions, speakers a requested to furnish either complete papers or 400-500 word abstracts, in triplicate, plus 50-word summaries for advan program mailings.

All material should be mailed on before June 15, 1961 to the NERE 1961 Program Chairman: F. K. Willebrock, Pierce Hall, Harvard Universit Cambridge 38, Mass.

Authors will be notified of paper acce tance or rejection by August 1, 1961.

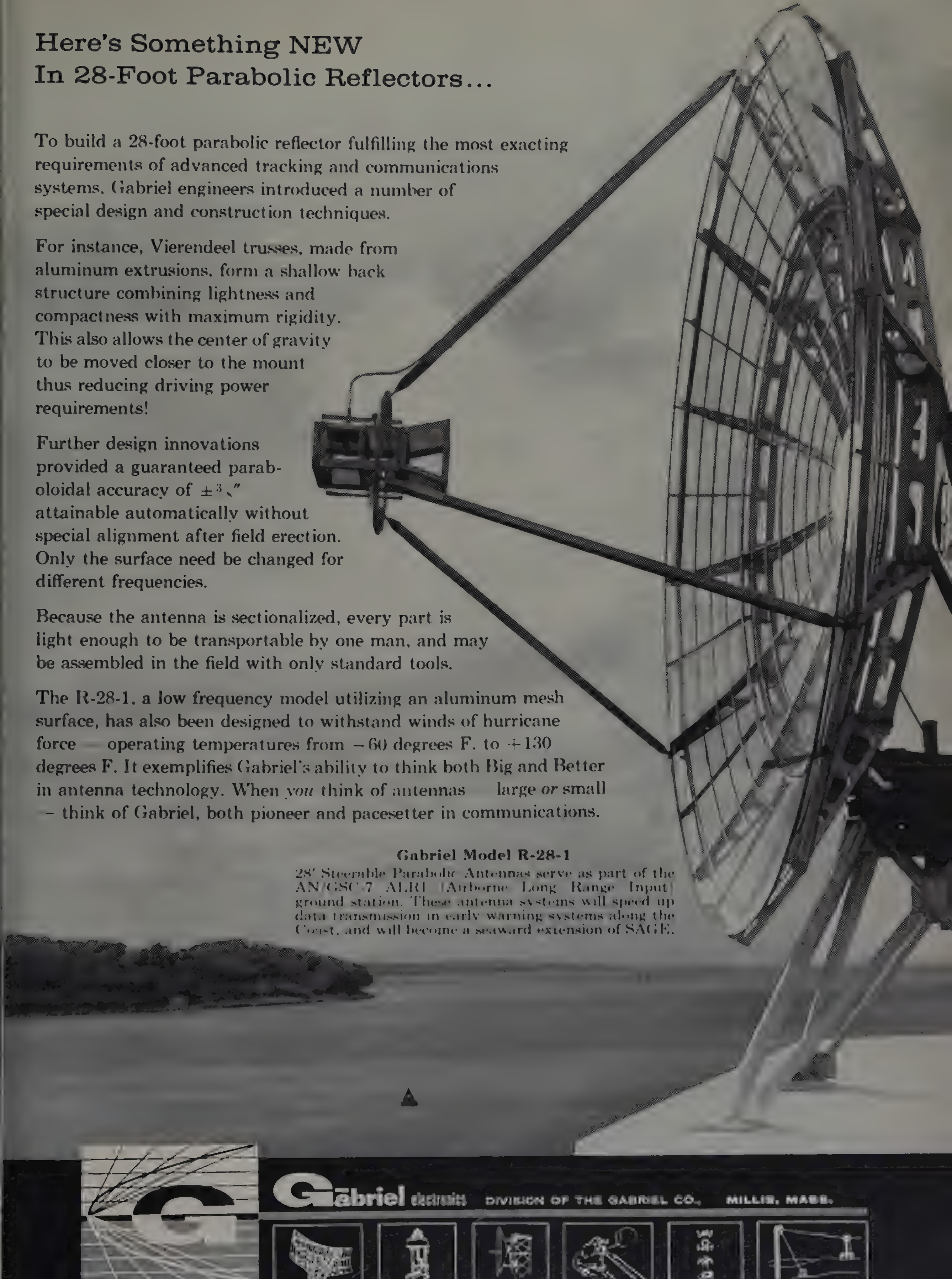
— *m w j* —

WINSOR WILL MANAGE ADVANCED ELECTRONIC DEPT.

Keith L. Winsor has joined Electr Optical Systems, Inc., Pasadena, Cal., Manager of the Advanced Electronics D partment of the Advanced Electronics Information Systems Division, where will be engaged in the application of ne and conventional circuit design to eng neering problems.

Winsor previously was with Wianc Engineering Co., where, as Project Chi he was in charge of the Components Se

(*Continued on page 38*)



Here's Something NEW In 28-Foot Parabolic Reflectors...

To build a 28-foot parabolic reflector fulfilling the most exacting requirements of advanced tracking and communications systems, Gabriel engineers introduced a number of special design and construction techniques.

For instance, Vierendeel trusses, made from aluminum extrusions, form a shallow back structure combining lightness and compactness with maximum rigidity. This also allows the center of gravity to be moved closer to the mount thus reducing driving power requirements!

Further design innovations provided a guaranteed paraboloidal accuracy of ±3/[illegible]" attainable automatically without special alignment after field erection. Only the surface need be changed for different frequencies.

Because the antenna is sectionalized, every part is light enough to be transportable by one man, and may be assembled in the field with only standard tools.

The R-28-1, a low frequency model utilizing an aluminum mesh surface, has also been designed to withstand winds of hurricane force — operating temperatures from −60 degrees F. to +130 degrees F. It exemplifies Gabriel's ability to think both Big and Better in antenna technology. When *you* think of antennas — large *or* small — think of Gabriel, both pioneer and pacesetter in communications.

Gabriel Model R-28-1

28' Steerable Parabolic Antennas serve as part of the AN/GSC-7 ALRI (Airborne Long Range Input) ground station. These antenna systems will speed up data transmission in early warning systems along the Coast, and will become a seaward extension of SAGE.

Gabriel electronics DIVISION OF THE GABRIEL CO., MILLIS, MASS.

PIONEERS IN ANTRONICS

AIRPORT SURVEILLANCE RADAR ANTENNAS

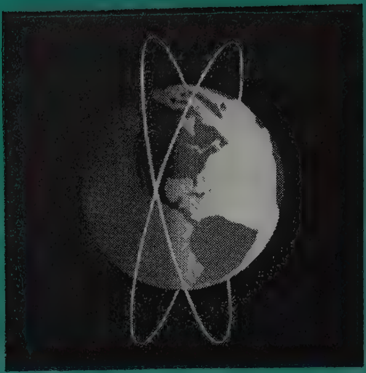
ROTARY JOINTS

POINT-TO-POINT COMMUNICATION ANTENNAS

FEEDS AND HORNS

DRONE & DRONE CONTROL ANTENNAS

RESEARCH & DEVELOPMENT



LUNAR PROBE

The moon — lacking an erosive atmosphere — may hold the key to the history of the solar system. Because of this lack of atmosphere, oceans, and wind, lunar explorations may help solve fundamental, universal questions.

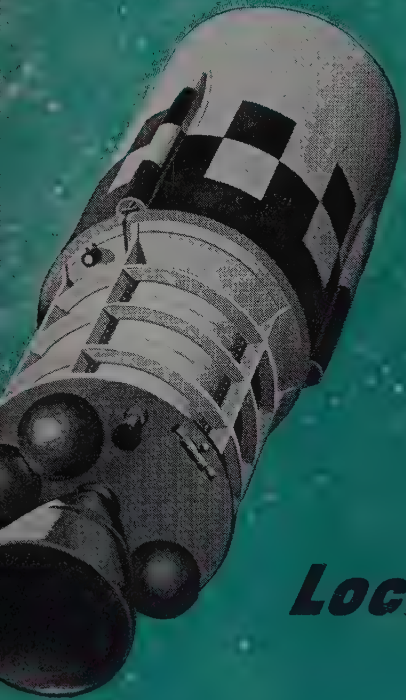
Logically, the moon will be the first objective in the exploration of space. Initially the moon itself will be photographed and instrumented; then manned observation stations will be established for astronomical and meteorological purposes. In time, the moon will serve as an intermediate station enroute to other planets — step by step into infinite space.

The National Aeronautics and Space Administration's Lunar Program will utilize Lockheed's AGENA B satellite to play a significant part in forthcoming lunar explorations — as well as a host of other scientific space missions. The NASA lunar launch in 1961-62 will utilize the highly reliable Lockheed AGENA as second stage to carry the RANGER spacecraft. The AGENA will provide the extremely critical guidance and controls necessary to place the RANGER on the required lunar impact trajectory.

The lunar probe application demonstrates the versatility, reliability and success of the AGENA vehicle in Lockheed's satellite and spacecraft programs. Developed for the Air Force for use in the DISCOVERER program, the AGENA also is utilized in the MIDAS missile defense alarm system. Noted for a record of outstanding accomplishments, the AGENA is credited with being the first to be placed on a polar orbit; first to achieve a precise, predicted and nearly circular orbit; first to attain attitude control on orbit; first to eject a reentry capsule which was successfully recovered. The AGENA can be modified for a variety of missions such as navigation, geophysical investigations, long-range communications and deep space probes.

Lockheed's capability in satellites and spacecraft, manifested by such an achievement as the AGENA, encompasses the entire field. It includes current and long-range programs such as interplanetary probes, global and space communication systems, and manned space travel.

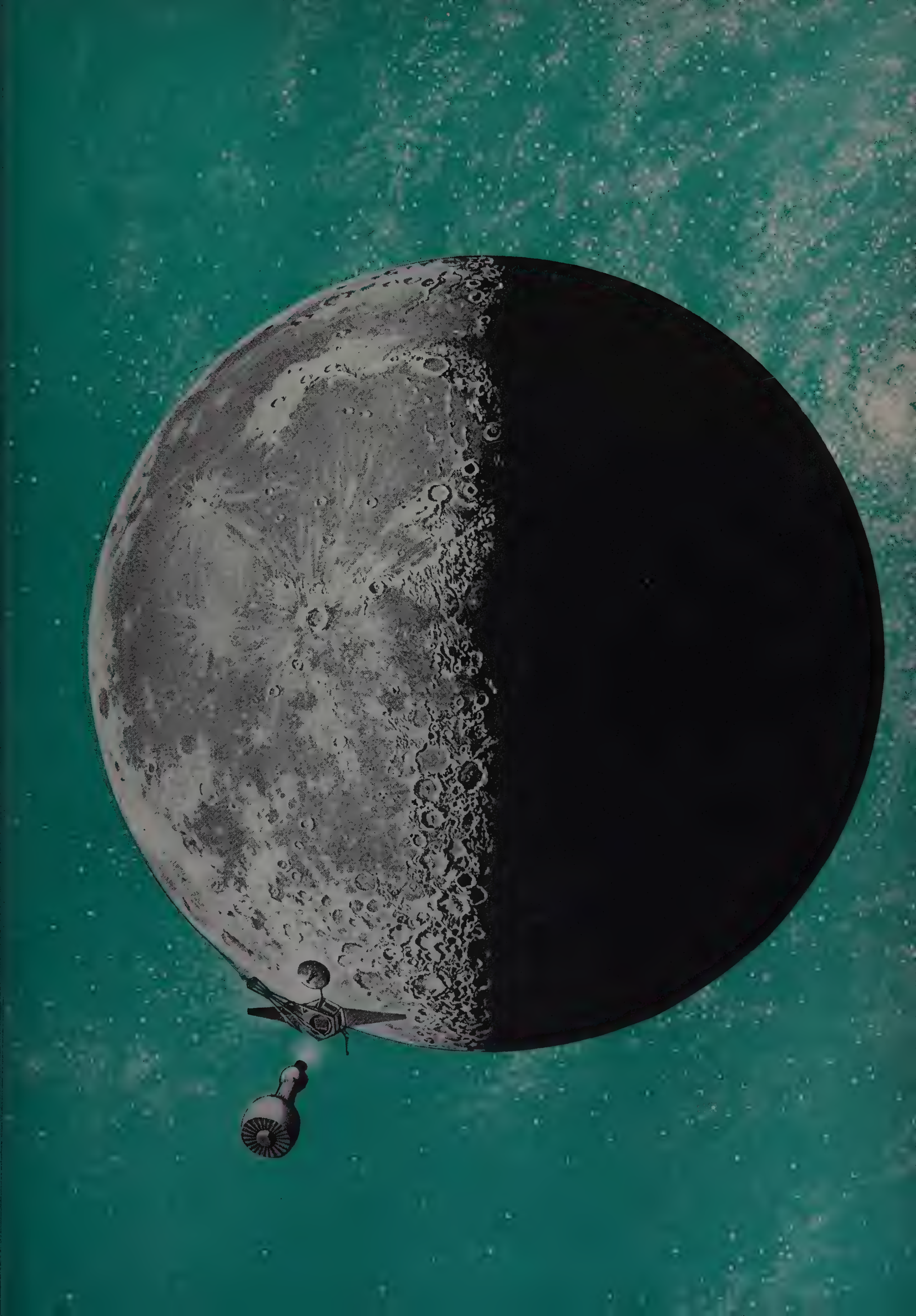
Engineers and Scientists: The accomplishment of such programs offers challenging opportunities to engineers and scientists in the research, design, development, test and operation phases of these programs. If you are experienced in work related to any of the above areas, you are invited to write: Research and Development Staff, Dept. M-29B, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.



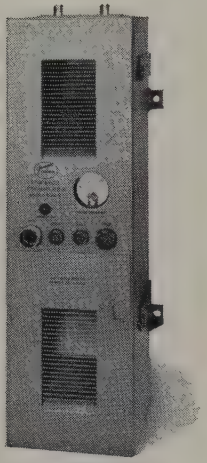
Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the
Air Force AGENA Satellite in the DISCOVERER and MIDAS Program

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • HAWAII



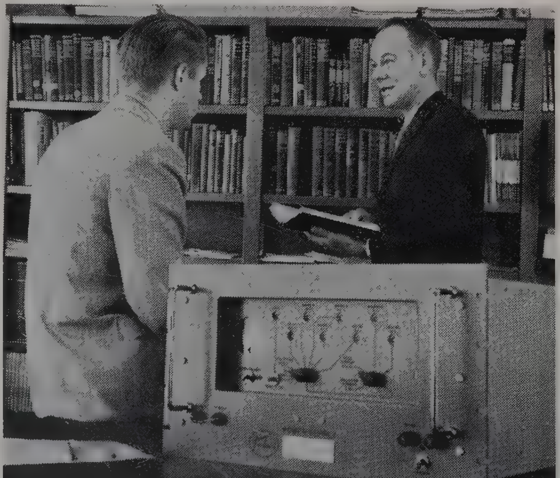
Granger Associates / Translating radio theory into practical radio hardware



PREAMPS: 550–10,750 MC / NOISE FIGURE 8 DB NOMINAL

This is a low noise (8 db nominal) solenoid focused, air-cooled traveling wave tube preamplifier, packaged for outdoor mounting. It is one of a family that covers the entire 550 Mc to 10,750 Mc spectrum. (Another group of G/A preamplifiers utilizes slab-focused tubes and covers the C and X bands.) All use MIL-spec components and construction techniques throughout, and are designed for military environments. Other microwave equipments from Granger Associates include wide-band antennas, receivers, r-f sources and ECM systems. May we send you further technical information?

Granger ASSOCIATES



Granger Associates / 974 Commercial Street / Palo Alto, California / DAvenport 1-4175

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Industry News

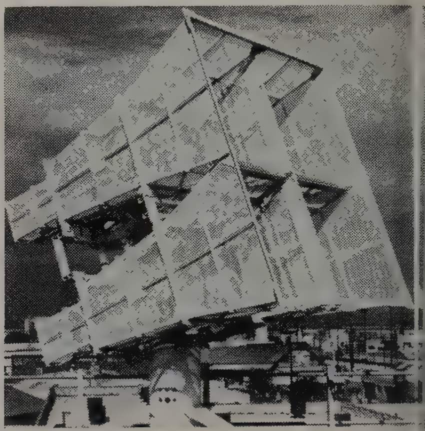
(Continued from page 34)

tion which was responsible for the design of new electronic products. He had been associated with Wiancko since 1952.

Winsor received his BS degree in electrical engineering from California Institute of Technology in 1952. He is a member of the Institute of Radio Engineers.

— m w j —

AUTOTRACK ANTENNA DESIGNED BY ELECTRONIC SPECIALTY



Development of a multi-purpose UHF Autotrack Antenna is announced by Electronic Specialty Co., Los Angeles, Calif. This is a variable polarized interferometer antenna system for operation in both the 225 MC band and the 450 MC band. Exclusive of pedestal, the system weighs less than 650 pounds, can handle continuous power of two kilowatts at one frequency in the 450 MC band while receiving in both bands, and can provide error signals for automatic tracking in both azimuth and elevation.

The first units are being used for the Geodetic SECOR (SEquential COllation of Range) system currently being built by Cubic Corporation under contract to the Army Map Service, Corps of Engineers. SECOR, which measures the distance to satellites, is expected to produce the most accurate data obtainable on the locations of continents, islands, and other landmarks around the globe as well as promising to provide global and space-vehicle navigation with previously unattainable accuracies.

— m w j —

MEYER NAMED VICE-PRESIDENT OF ADCOLE

Dr. Maurice A. Meyer, well-known Doppler navigation pioneer, has been name Vice-President of the Adcole Corp., Cambridge, Mass. The announcement wa made by Mr. Addison D. Cole, Presiden of the electronics R & D firm.

For the past five years, Dr. Meyer hel the positions of Director of Advanced Development and Chief Engineer at Labor tory For Electronics, Inc., Boston, Mas During this period he pioneered the development of Doppler navigational sy

(Continued on page 41)

THE PRACTICALITY OF PHOTO-ETCHED MICROWAVE CIRCUITS

with particular emphasis on loss and power handling characteristics.

by JAMES W. CHRISTIAN
Project Engineer, Instrument Division
LABORATORY FOR ELECTRONICS, INC.

lthough the advantages of printed circuit chniques in the lower frequency regions e well known, it is not so well known hat printed circuits at microwave frequen- es now enjoy the same advantages: light weight, small size, reproducibility, and conomy. Even further, these multiple advantages of photo-etched transmission line ow permit routine solutions to transmis- on line and antenna problems once con- dered virtually impossible by conventional waveguide or coaxial line techniques.

n applying photo-etched techniques to microwave circuits, we occasionally find that prospective users believe that the losses may be too high and power handling capabilities too low. Such beliefs are not true for most applications. We hope that the graphs shown, particularly those of attenuation and power handling capacity, will dispel these impressions.

The planar transmission system used in photo-etched applications evolved from the coaxial line. As shown in figure 1, if a coaxial line is deformed until the outer and inner conductors become long rectangles, hen removal of the side walls results in a at transmission line. Its form factor is ideally suited to printed circuit techniques.

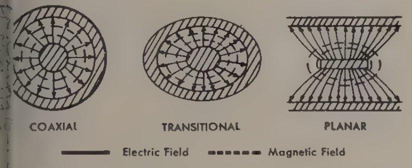


Figure 1

This planar line is substantially free from radiation losses. Almost all of the field is concentrated in the region of the inner conductor, and since the two outer conductors are at the same potential, the plane of the center conductor is an essentially field-free region. As in a coaxial line, the TEM mode is used in practical applications.

LFE's photo-etched components are called Epsi-line, a contraction of Epsilon (from dielectric constant) and transmission line. However, Epsi-line is more than a trade name. It includes true production engineering and outstanding features such as an outer encapsulation that provides > 120 db attenuation to radiation pickup from outside sources.

Physically, Epsi-line is made from thin copper-clad laminates, usually 1/16″ thick, wherein unwanted copper is removed by photo etching. The space between inner and outer plates is filled with a low-loss dielectric material, and hence components become much smaller from this fact alone. The wave length in the line, λg, is shortened almost 40% since $\lambda g = \frac{\lambda o.}{\sqrt{\epsilon}}$, where λo is the free space wave length and ϵ is the dielectric constant. ($\epsilon = 2.53$ for the commonly used laminate.) Also, circuit elements may be placed close together without interaction. Cross talk at 4000 mc/s is roughly 70 db per 1/4 inch.

CHARACTERISTIC IMPEDANCE

The characteristic impedance of Epsi-line is determined by the dimensions of the inner conductor, the dielectric constant of the laminate, and the spacing between the ground planes. Since these can be controlled very accurately, homogeneity of impedance is assured, and internal junction VSWR's of < 1.05 are readily maintained. Note in figure 2 that a wide range of impedance levels is practicable.

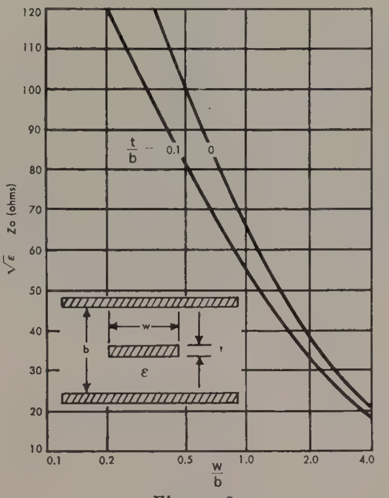


Figure 2

ATTENUATION

As in all transmission lines, the attenuation or loss factor is composed of three parts: losses in the conductors, in the dielectric medium, and by radiation. But since losses by radiation and losses in the ground planes are extremely small (10^{-3}) compared with the other losses, attenuation can be expressed as the sum of inner-conductor and dielectric losses. For average dimensions of center conductor and for Rexolite 1422 dielectric, the attenuation per foot of line is given in figure 3. Only a very few inches of line are used in any component. Consequently, even at X-band, the insertion loss of Epsi-line components is less than 0.4 db.

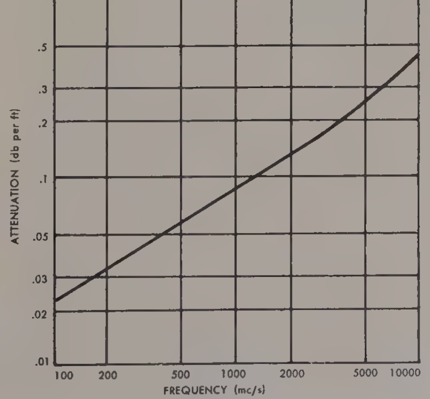


Figure 3

POWER RATING

As one might expect, average power rating depends on the allowable temperature rise of the inner conductor. It is also interesting that the temperature rise in the inner strip of Epsi-line is nearly the same as in an ordinary coaxial line having the same characteristic impedance and attenuation per unit length.

For a temperature rise of 39°C, $Z_0 = 50$ ohms, $t = 0.002''$, $w = 0.093''$, $b = 0.125''$, $\epsilon = 2.53$ (Rexolite 1422), figure 4 gives the average power capabilities of representative Epsi-line components. At X-, C-, S-, and L-bands, average power capabilities are approximately 100, 150, 200, and 500 watts, respectively.

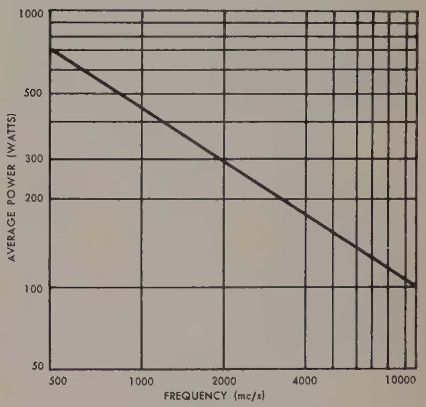


Figure 4

The peak-power capability of standard configuration Epsi-line is restricted by a small air gap at the edge of the photo-etched center conductor. Under the same conditions and dielectric mentioned above for average-power rating, the peak power rating is 25 kilowatts with a 2:1 safety factor. However, the air gap can be removed by special processing techniques. This plus appropriate internal encapsulation permits peak ratings as high as 1.5 megawatts.

With ratings such as these, Epsi-line microwave components are truly practical. In the frequency range 500 to 11,000 mc/s, LFE manufactures a wide variety of cataloged components: balanced crystal mixers, directional couplers, hybrids, attenuators, multi-terminal power dividers, as well as any combination of such devices in a single package. Input VSWR's are generally less than 1.2 over wide frequency ranges. The total encapsulation, internal and external, assures constant peak performance protected from radiation, moisture, corrosion, shock, and vibration. For further information, write to Mr. Perry Pollins at the address below.

LABORATORY FOR ELECTRONICS, INC.
Instrument Division
714 Beacon Street, Boston, Massachusetts

Circle Reader Service Card 23

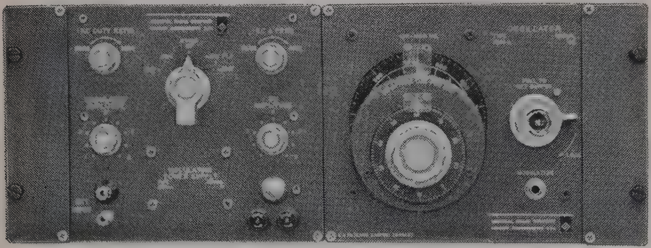
a new UHF OSCILLATOR

450 to 1050 Mc

OSCILLATOR
TYPE 1361-A
SERIAL 108
450-1050 MC
PULL TO
50Ω OUTPUT
LOCK
MODULATION
GENERAL RADIO COMPANY
CONCORD MASSACHUSETTS USA
US PATENTS 2367681 2548457

Type 1361-A Oscillator........$285.

- Butterfly Tuning Circuit — no sliding contacts
- Frequency Scale Calibration Accuracy ±1%; constant 0.1% frequency change for each vernier division. Warm-up frequency drift is 0.2%, maximum.
- Modulation Capabilities — sine wave, square wave, or pulse from external source; 40v required to produce 30% sine-wave modulation into
- High Output — 100 mw minimum into 50-Ω load, adjustable at panel by calibrated 80-db attenuator.
- Complete Shielding, including use of ferrite-loaded filters and ceramic shaft, reduces stray fields to very low values.
- Sweep Drive Capability using G-R sweep and dial drives.
- Small Size: 8″ x 7″ x 8¼″; only 7 lbs.
- Power Supply Recommended: 1201-A Regulated Power Supply $85, for cw; 1263-B Amplitude Regulating Power Supply $355, for constant output level; 1264-A Modulating Power Supply (below).



Type 1361-A Oscillator and Type 1264-A Modulating Power Supply conveniently mount in a relay rack with Adaptor Plates, Type 480-P-416, **$6.**

NEW MODULATING POWER SUPPLY

. . . for high-level pulse and square-wave modulation of Vhf-Uhf Unit Oscillators.

OUTPUTS: Square Waves — adjustable from 160v to 210v; internally generated 850 to 1150 cps, with high stability; externally generated 20 to 50,000 cps from sine or square-wave source.

Pulses (externally generated) — 160v to 210v at rates up to 100 kc, pulse durations from 1.5 μsec to square wave (determined by external generator), less than 1.5 μsec rise and decay times for typical oscillator load, overshoot less than 5%.

Regulated DC — adjustable from 200v to 300v, 50 ma (max)

Unregulated AC — 6.3v; 2.1a (max)

INPUT: 115v or 230v, 50-1000 cps, 85 watts
Small Size: 7″ x 8″ x 8″; 12 lbs. **Price: $285.**

12 Other Unit Oscillators Cover the Range from 20 cps to 7,425 Mc

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GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS

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Industry News

(*Continued from page 38*)

ems for aircraft, being chiefly responsible or the design and development of the APN-78, APN-105, APN-116 and APN-119 Doppler systems. He had been associated with LFE for 13 years.

— *m w j* —

PAPERS REQUESTED FOR SYMPOSIUM

Papers are requested for the East Lansing Symposium on Engineering Writing and Speech, which will be held October 16-17 at the Kellogg Center for Continuing Education, Michigan State University, East Lansing, Michigan.

Theme for the papers will be "Communicating Ideas — the Modern Engineer's Function." A 500-word summary should be submitted by July 15, 1961 to: J. D. Chapline, Program Chairman, Philco Corporation, 3900 Welsh Road, Willow Grove, Pa.

— *m w j* —

GREATEST SHORTAGE NOT MANPOWER SAYS CADILLAC'S BARTON

"I am shocked by the attitudes I see in so many of today's junior executives. Frankly, our national shortage is not man power; it's guts'!"

The speaker was Lon D. Barton. The time was April, 1957, but the president of Cadillac Associates Inc., Chicago, Ill., feels his remarks are even more appropriate today than they were in 1957.

Barton reports that in his more than 30 years of executive search and placement work he has never heard so much talk about company benefits and corporate security and less talk about risks and rewards as he finds among today's junior and even some senior executives.

"There may have been more excuse for it in 1957, but there certainly isn't today with our continuing trend toward more paternalistic buffers against economic trauma in the executive class," Barton said.

The Cadillac president explained that at every turn he hears young executives who should be concerned with potential advancement center their thoughts about stability and security. "Nine out of 10 of today's young 'organization men' are looking for a position as assistant to a president (preferably a sick president) where they can enjoy all the prestige, authority, security and income of a management position yet remain free from full executive responsibility. Most are unwilling to prove themselves by hard work," he explained.

On the other hand, Barton and his counselors see hundreds of men who are loaded with security and who are miserably unhappy in their jobs yet they are, by and large, unwilling to resign security to achieve greater success and the sense of accomplishment which goes with real executive status.

— *m w j* —

(*Continued on page 42*)

19 MICROWAVE SWITCH TYPES FROM TRANSCO

Transco manufactures the most complete line of microwave switches, coax and waveguide (19 different types), for all frequencies including P, L, S, C, X and K band and many variations—solenoid and motor actuators, SPST to SP6T, DPDT, transfer, 4 actuator voltages, 8 RF connector types, high and low power. All switches have excellent RF characteristics and are built to military specifications. For information on the 19 types, or "type number 20" for your specific application, write or call Transco Products, Inc., 12210 Nebraska Avenue, Los Angeles 25, California, BRadshaw 2-5687. Application engineers and representatives throughout the United States and Canada.

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BACKSCATTER

BACKSCATTER

BACKSCATTER

BACKSCATTER

You'll be interested, if your field involves the study of ionospheric variations, in the ATI *Backscatter Sounders.* ATI sounders are basically radar-like instruments and generally operate in the HF and VHF regions at peak power levels of several kilowatts.

Applied Technology, Inc. has developed inexpensive specialized backscatter sounding equipment in the range 10 to 54 Mc with peak output power levels in excess of 20 kilowatts. Echoes to ranges in excess of 10,000 kilometers are usually obtained. Swept frequency operation provides considerable versatility and allows the evaluation of irregularities within the ionosphere as a function of frequency and time.

Our presently developed sounding equipment may be useful for your requirements. If not, our staff is available to design and produce new systems according to your particular operational situation. Ionosphere Instrumentation is another of the development areas in which the ATI "Concept to Reality" philosophy has resulted in superior equipment meeting strict performance specifications.

Engineers who want to become part of a task-oriented organization where the individual participates "from Concept to Reality" are invited to submit resumes to Dr. John L. Grigsby, Chief Engineer. Employee stock participation is available.

ATI

AREAS OF SPECIALIZATION:
- ELINT Receiving Systems
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- Broad-Band Amplification
- Ionosphere Research Instrumentation
- Radio Astronomy Instrumentation
- Microwave Radiometry

APPLIED TECHNOLOGY, INC.
930 Industrial Avenue • Palo Alto, California

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Industry News

(*Continued from page 41*)

MacDONALD WILL CONDUCT EXPERIMENTS FOR GT & E LAB

Dr. Alexander D. MacDonald has joined the Microwave Physics Laboratory of General Telephone & Electronics Laboratories, Inc., Palo Alto, Cal., as a senior engineering specialist.

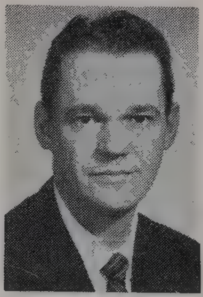
In making the announcement, Lt. Gen. James D. O'Connell (Ret.), vice president of the GT&E laboratories, said that Dr. MacDonald will direct a program to study microwave breakdown phenomena in ionized gases. A series of experiments will be conducted under Dr. MacDonald's direction to measure the basic plasma parameters of air in order to fully understand the microwave breakdown properties therein.

Dr. MacDonald previously was professor of physics at Dalhousie University, Halifax, Canada. He had been associated with the University since 1949. In addition, he served as a research scientist with the Defense Research Board in Canada, and spent a one-year sabbatical leave at the Microwave Physics Laboratory working on gaseous electronics problems.

In 1945 Dr. MacDonald received the BS degree in mathematics and in 1947 the MS degree in physics from Dalhousie University. Two years later he was awarded the PhD degree in physics from Massachusetts Institute of Technology.

— *mwj* —

HAWLEY WILL DIRECT SALES IN SOUTH AMERICA



James C. Hawley, former advisor on electronics and communications to the Venezuelan Navy in the U. S. Naval Mission to Venezuela, has been appointed by Raytheon Co. as regional supervisor of international sales and services in South America.

From the new Raytheon offices in Lima, Peru, Hawley will direct sales and services for Raytheon Company's electronic components and equipment throughout South America. The address of the Lima office is Apartado 2357.

For the past two years he has directed the planning and engineering of the electronic modernization for the Venezuelan Navy's major classes of destroyers and the naval shore communication system.

— *mwj* —

MANNING NAMED ASSISTANT TO VICE PRESIDENT

Simplex Wire & Cable Co., Cambridge, Mass., has announced the association of V. Reed Manning as Assistant to the Vice President — Engineering. Mr. Manning will be responsible for communication and electronic systems.

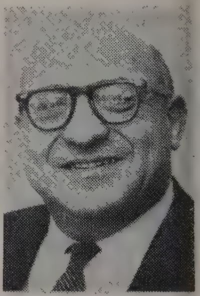
Mr. Manning was recently with Alpha Corp. as Executive Assistant to the Vice President, consulting in the design and construction of communication systems.

Engineering projects in Mr. Manning's background include the supervisory design of the complex microwave system linking the operational centers of the Pacific Missile Range for Collins Radio Co., Engineering Supervisor on the Distant Early Warning Line and fire control radar systems for Western Electric Co.

He is a graduate of Bowdoin College and is a member of the Institute of Radio Engineers and of the IRE Professional Group — Communication Systems.

— *mwj* —

MANNHEIMER JOINS LOCKHEED



Dr. Manfred Mannheimer, has joined the Systems Research Center of Lockheed Electronics Co., Bedminster, N. J. He will be engaged initially on projects involving propagation, nuclear fusion and reentry.

Dr. Mannheimer was born in Frankfurt-on-Main, Germany, and received the Ph.D. degree from Frankfurt University, where he majored in physical chemistry and minored in mathematics and physics.

His past experience in the United States includes engineering assignments in optics, missile guidance, interplanetary navigation, electro-chemistry, plasma physics and nuclear physics. Dr. Mannheimer holds memberships in the American Physical Society, American Chemical Society, and Sigma Xi.

— *mwj* —

LFE ACQUIRES PLANT SITE

Laboratory For Electronics, Inc., Boston, Mass., has taken the first step in a planned, eight-year facilities expansion program with acquisition of a 115-acre site on Route 128 in Danvers, Mass.

Immediate plans for its use call for construction to begin this spring on a 60,000

(*Continued on page 44*)

WHY PAY for superhet sensitivity in range monitoring, lab work when the Melabs

INDICATOR
RECEIVER
SIGNAL STRENGTH
FREQUENCY KMC

TEST RECEIVER

permits field strength readings and rf pulse analysis at extremely low cost!

For only $900.00, a microwave receiver of moderate sensitivity and high selectivity, usable with separate synchroscope for pulse observation! The first high-performance, low-cost receiver of its type on the market!

These small, transistorized receivers are available today for the U, L, S, C, X and P bands, with similar models soon to be available in these ranges: 18-26.5 KMC, 26.5-40 KMC. Battery-operated cabinet models also available on special order for portable field use.

Receivers for all frequency bands are identical except for tuning cavity and dial. The DRO-4A display unit designed for use with the receiver can be used with all models, is packaged separately for maximum flexibility. Only one interconnecting video cable is required.

SPECIFICATIONS

Frequency Ranges:	Model RCU-1: 400 MC-1 KMC Model RCL-1: 1-2 KMC Model RCS-1A: 2-4 KMC Model RCJ-1: 4-8 KMC Model RCX-1: 8-12.4 KMC Model RCP-1: 12.4-18 KMC
Sensitivity:	– 40 dbm minimum
Selectivity:	1% at 3 db (maximum)
Video Bandwidth:	4 MC
Dial Accuracy:	1%
Weight:	Receiver, 15 lbs.; display, 30 lbs.
Size:	Receiver, 3½″ x 15″ x 19″; display, 7″ x 15″ x 19″
Sync sweep speed:	10, 100, 10,000 μsec
Price:	$900.00 (add $150 for model RCX-1 or Model RCP-1) DRO-4A Display Unit, $900.00

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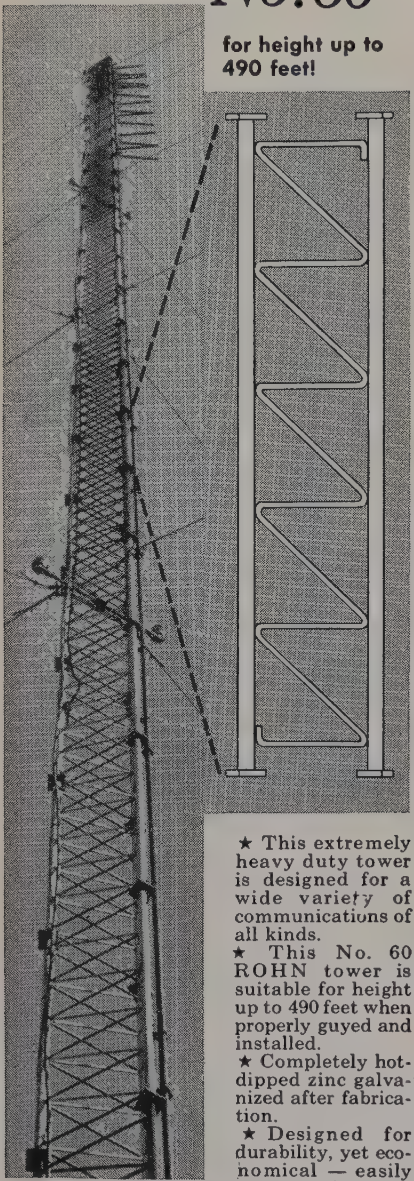**ROHN COMMUNICATION TOWER**

No. 60

for height up to 490 feet!

★ This extremely heavy duty tower is designed for a wide variety of communications of all kinds.
★ This No. 60 ROHN tower is suitable for height up to 490 feet when properly guyed and installed.
★ Completely hot-dipped zinc galvanized after fabrication.
★ Designed for durability, yet economical — easily erected and shipped. ROHN towers have excellent workmanship, construction and design. Each section is 10 feet in length.

Shown above is a ROHN No. 60G tower used for FM broadcasting, installed to a height of 300 feet.

FREE

Details and complete engineering specifications gladly sent on request. Also ROHN representatives are coast-to-coast to assist you.

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"Pioneer Manufacturers of Towers of All Kinds"

Industry News

(*Continued from page 42*)

square foot research and development facility, according to Henry W. Harding, LFE president. "We hope to have the building ready for occupancy by November," he said.

"An important factor in our choice is that the land is adjacent to the Beverly, Mass., airport. Access to the airport will enable LFE to consolidate flight test and radar facilities now located at other Massachusetts airports at the same place we will eventually have all of our other facilities," Mr. Harding explained.

"While the purchase gives LFE a sizeable tract of prime industrial land for construction of manufacturing and administrative facilities," he stated, "it does not mean we will make an immediate move out of the nearly one-half-million square feet of space we now lease in metropolitan Boston.

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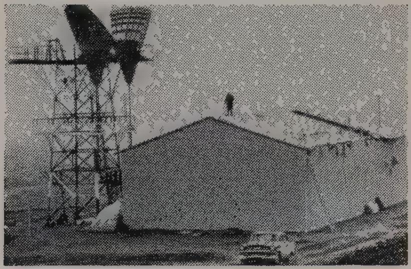
BMEWS TELEPHONE CIRCUITS ANNOUNCED



The first telephone circuits of the Ballistic Missile Early Warning System (BMEWS) communications network have been made available for U.S. Air Force use between the missile detection station at Clear, Alaska and Fairbanks, the Western Electric Co., N.Y., has announced.

This initial link from Clear is via a high quality radio system connecting the Air Force stations at Murphy Dome and Pedro Dome to the Alaskan Communications System office at Fairbanks.

These four stations are the first of 34 U.S. Air Force microwave ("line of sight") and tropospheric scatter ("over the horizon") radio stations being installed by Western Electric to provide two communication routes of unprecedented reliability and quality passing near, and available to the principal Alaskan cities of Anchorage, Fairbanks, Juneau and Ketchikan.

The BMEWS communication system from Clear will become operational sometime this summer. It will connect the huge Alaskan missile detection station with the North American Air Defense Command (NORAD) at Colorado Springs, Colorado.

— *m w j* —

HERBERT FINKE APPOINTED TO NEW POSITION

Herbert A. Finke has been named to the new position of vice president and general manager of Bomac Laboratories, Inc., Beverly, Mass., according to an announcement by President Harold C. Booth.

Mr. Finke will assume his new duties immediately, leaving his position as director of long-range planning for Varian Associates of Palo Alto, California, parent company of Bomac.

Mr. Finke joined Varian in 1960. Prior to that he was vice president and general manager of Polytechnic Research and Development Corp., a subsidiary of Harris-Intertype Corp. of Cleveland, Ohio.

A graduate of Massachusetts Institute of Technology, Mr. Finke received his master's degree in electrical engineering from Polytechnic Institute of Brooklyn. He is the author of a number of scientific papers and holds some 10 U.S. patents for electronic devices.

— *m w j* —

RCA OPENS WEST COAST LAB

A new microwave engineering laboratory has been opened by Microwave Tube Operations of the RCA Electron Tube Division at 6801 East Washington Boulevard, Los Angeles, Cal.

The laboratory will operate in conjunction with the Operations' other facilities at Harrison and Princeton, N. J.

"Special requirements of our West Coast customers of traveling-wave tubes, magnetrons and pencil tubes can now be given on-the-spot attention by application experts located at the new laboratory," said C. C. Simeral, Jr., Manager, Microwave Tube Operations. He added that another important function of the laboratory will be to develop and produce sampling quantities of RCA solid-state microwave components including oscillators, amplifiers and other related devices.

Mr. Simeral said these components combine semiconductor diodes and microwave circuitry in rugged, low-cost packages that can be used to perform complete system functions.

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WEBSTER APPOINTED MILITARY PROJECTS MANAGER

PRD Electronics, Inc., Brooklyn, N. Y., manufacturer of microwave and electronic instruments, has appointed Edward Webster as military projects manager, it has been announced by Henry H. Michaels, Jr., president.

Mr. Webster has been in the electronics industry since 1941 and during World War II served in the capacity of electronics officer for the U. S. Coast Guard. Prior to joining PRD, he had been employed by the Bureau of Aeronautics in Washington, D.C., and later at Headquarters, U.S. Pacific Missile Range, Point Mugu, California where he was head of the Equipment Support Division.

Mr. Webster holds a BS degree from the University of Maryland, an LLB degree from George Washington University and an LLM degree from National University.

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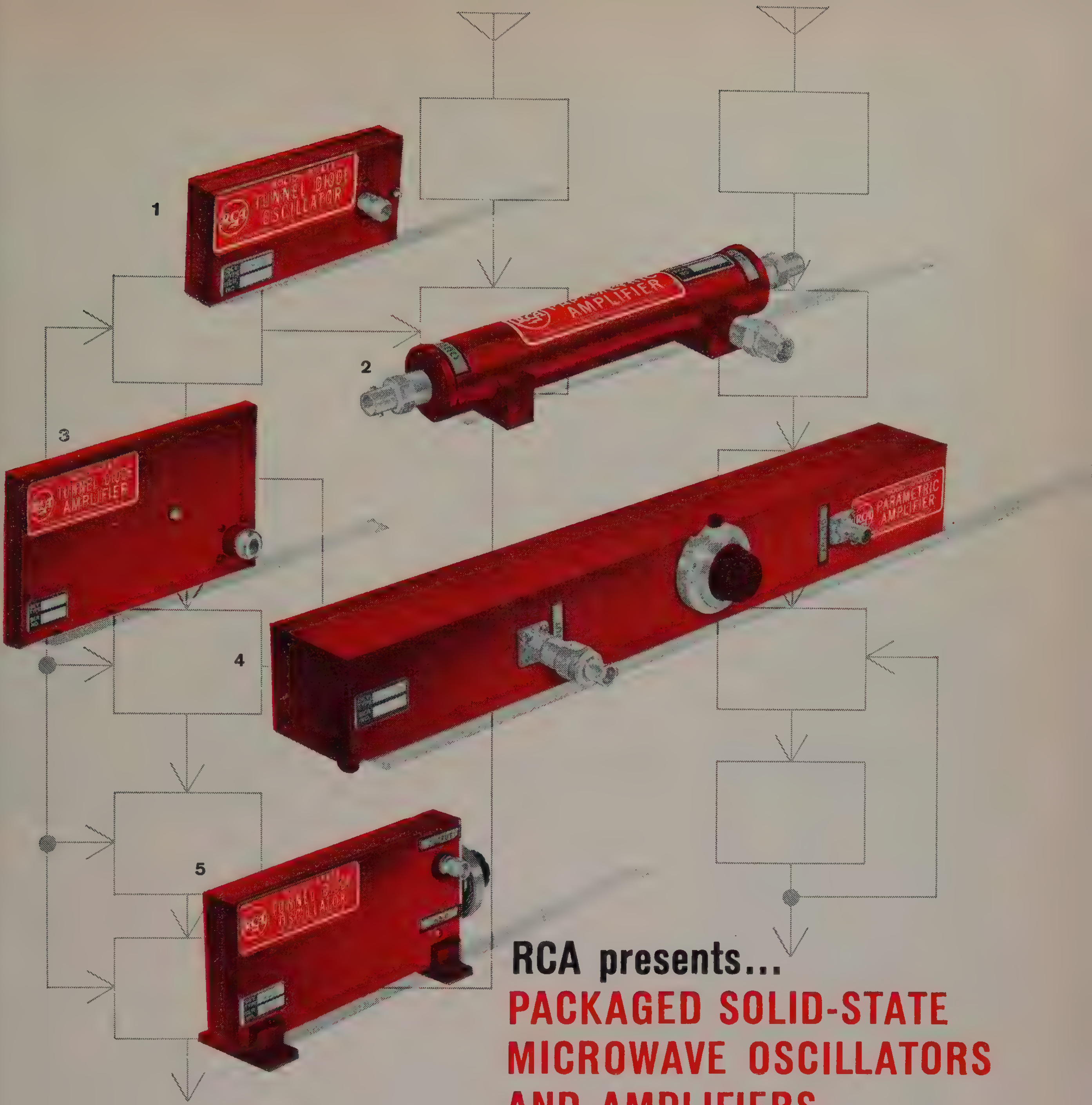
(*Continued on page 46*)



RCA presents...

PACKAGED SOLID-STATE MICROWAVE OSCILLATORS AND AMPLIFIERS

ow, RCA takes a major step ahead in microwave technology—to integrate packaged crowave circuits with RCA developed solid-state diodes and provide an important, new e of components for the needs of microwave designers. Low power requirements, d compact packaging using RCA Semiconductor and Materials Division's latest tunnel d varactor diodes open new possibilities for miniaturization, improved systems reliility, and systems cost reduction. Here are the first members of a growing family packaged microwave circuits.

In addition to the performance characteristics of the packaged circuits shown here, RCA lid-State Microwave Oscillators and Amplifiers can be designed to meet your special quirements for gain, power, frequency, and noise characteristics. For delivery quotans and technical data on circuits to meet your needs, contact the RCA Field Office arest you. Or write: Microwave Marketing, RCA Electron Tube Div., Harrison, N. J.

1. **Fixed-Tuned Tunnel-Diode Oscillator** (Dev. No. SS-107) Delivers a minimum power output of 1 milliwatt at your specified frequency between 500-2000 Mc. DC input; 160 ma at 0.40 volt.
2. **Helix Parametric Amplifier** (Dev. No. SS-1000) Stable minimum gain of 15 db from 2200-2300 Mc with a 5-7.5 db noise factor. Typical saturated power output of 1 milliwatt; with 300 milliwatts pump power at 3000 Mc.
3. **Tunnel-Diode Amplifier** (Dev. No. SS-500) Stable minimum gain of 15 db from 1275-1325 Mc with 6 db max. noise factor, including typical circulator loss. Saturated power output of 30 microwatts. DC input; 10 ma at 0.1 volt.
4. **Tunable Low-Noise Parametric Amplifier** (Dev. No. SS-1002) Tunable with 5 Mc bandwidth from 1250-1350 Mc, with stable minimum gain of 15 db. Max. noise factor, 3 db. Saturated power output of 0.5 milliwatt, with 60 milliwatts pump power at 10,800 Mc.
5. **Tunable Tunnel-Diode Oscillator** (Dev. No. SS-100) Delivers a minimum power output of 0.3 milliwatt from 1050-1400 Mc. Coax. output. DC input; 30 ma at 0.2 volt.

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

RCA Electron Tube Division Field Offices

INDUSTRIAL PRODUCTS SALES

Detroit 2, Michigan, 714 New Center Building, TR 5-5600 • Newark 2, N. J., 744 Broad St., HU 5-3900 • Chicago 54, Illinois, Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Los Angeles, California, 6801 East Washington Boulevard, RA 3-8361 • Burlingame, California, 1838 El Camino Real, Ox 7-1620.

GOVERNMENT SALES

Harrison, N. J., 415 South 5th St., HU 5-3900 • Dayton 2, Ohio, 224 North Wilkinson St., BA 6-2366 • Washington 7, D. C., 1725 "K" St., N.W., FE 7-8500.

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VIDEO
AND
RF
AMPLIFIERS

Model 178
Video Amp.

Model RFA500
RF Preamp.

Model 172
Video Amp.

MINIATURIZED
TRANSISTORIZED
MILITARIZED

AEL has developed a wide variety of transistorized amplifiers including LOW NOISE, HIGH GAIN Video Amplifiers of wide dynamic range and LOW NOISE, BROADBAND RF Preamplifiers covering the VHF and UHF frequency bands.

Send us your specifications so we can adapt one of our many existing designs or supply a new design to meet your unique system requirements.

For laboratory application inquire about Models 120A and 173 Video Amplifiers.

Coaxial crystal detector mounts • 50 mc to 12 kmc

Waveguide Filters Band Pass and High Pass • 8.2 kmc to 40 kmc

Microwave Crystal Switches • 10 mc to 14 kmc

Horn Antennas Linearly or Circularly polarized • 1 kmc to 40 kmc

AEL ®

AMER. ELECT. LABS., INC.
121 N. 7TH ST., PHILADELPHIA 6, PA.
In Canada contact: Conway Electronic Enterprises Regd. Toronto, Canada

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Industry News

(*Continued from page 44*)

DeMORNAY-BONARDI EXPANDS

DeMornay-Bonardi, Pasadena, Cal., manufacturers of microwave test equipment, has purchased the D-B Corporation, Pasadena, for cash. D-B Corp. has been producing precision waveguide flanges to extremely close tolerances, and performing contract machine work. Buildings, facilities, personnel, and the D-B name, have been taken over by DeMornay-Bonardi.

According to Richard DeMornay, president and chief engineer of DeMornay-Bonardi, there will be no overall reduction in personnel resulting from the merger, although there was a planned reduction in supervisory personnel, usual in mergers of this type. The reduction in supervisory personnel was more than offset by the increase in direct labor.

Mr. DeMornay announces the following appointments and promotions for the expanded operation:
Frank Mead, previously with the D-B Corp., has been named assistant to the president—a newly-created position. William T. Brock, formerly chief microwave engineer for 5 years, has been appointed manager of research and development—another newly-created position.

Other appointments are: Nicholas Mammarella, manager of the drafting department; Ernest F. Steed, manager of the production laboratories; Alfred Lilge, manager of technical literature and quotations; John Hulbert, purchasing agent; Haskal Whitworth, production control manager, and M. G. Ekstrom, sales manager.

— m w j —

COMMITTEE HEADS LEAD WESCON EVENTS

An array of talent has been organized to lead the main committee functions of the 1961 Western Electronic Show and Convention, San Francisco, Cal. next August 22-25.

Albert J. Morris, WESCON board chairman, and O. H. Brown, chairman of the executive committee of WESCON's board, jointly announced appointments to head committee planning of a wide variety of activities associated with the West's largest technical conference and trade exhibition.

Dr. John V. N. Granger, convention director, will supervise the following: Technical Program — E. W. Herold of Varian Associates, chairman; L. G. Clarke of Stanford Research Institute, vice-chairman; Facilities — Robert Craig of Hanson Laboratory, Stanford University, chairman; H. M. Meyer of Stanford Research Institute, vice-chairman; Field Trips — Richard J. Reynolds of Hewlett-Packard Co., chairman; Robert E. Miller of Applied Electronics, Stanford University, vice-chairman.

Women's Activities — Mrs. Bernard M. Oliver of Los Altos Hills, chairman; Mrs. Norman H. Moore of Atherton, vice-chairman; All-Industry Banquet — John S. McCullough of Litton Industries, Inc., Electron Tube Division, chairman; Cortlandt Van Rensselaer of Dymec Division, Hewlett-Packard Co., vice-chairman; Future Engineers Show — Jack L. Melchor, chairman; Alan T. Waterman of Applied Electronics, Stanford University, vice-chairman; Hospitality — John A. Chartz of Dalmo Victor Co. and Donald B. Harris of Stanford Research Institute, co-chairmen.

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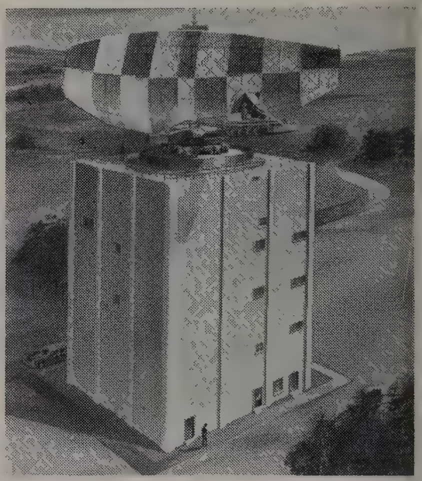
SEARCH RADAR SITE DUE TO BE INSTALLED



The first operational AN/FPS-24 Search Radar site will be installed at Point Arena, Cal., north of San Francisco, early this spring, according to 28th Air Division officials at Hamilton Air Force Base.

The 84-foot high, 5-story concrete building will house electronic equipment for new long range air defense radar and also double as an antenna base. The mammoth antenna system, including pedestal, feedhorn, and reflector, is one of the world's largest rotating radar structures. It will measure 120 feet wide by 50 feet high and weigh 137 tons. Screen-like reflector contains more than two miles of high strength aluminum and low temperature steel tubing.

The AN/FPS-24 radar is being built by the General Electric Company's Heavy Electronics Department, Syracuse, for use with the Air Force Air Defense Command's SAGE System.

— m w j —

TWO BALTIMORE FIRMS AFFILIATE

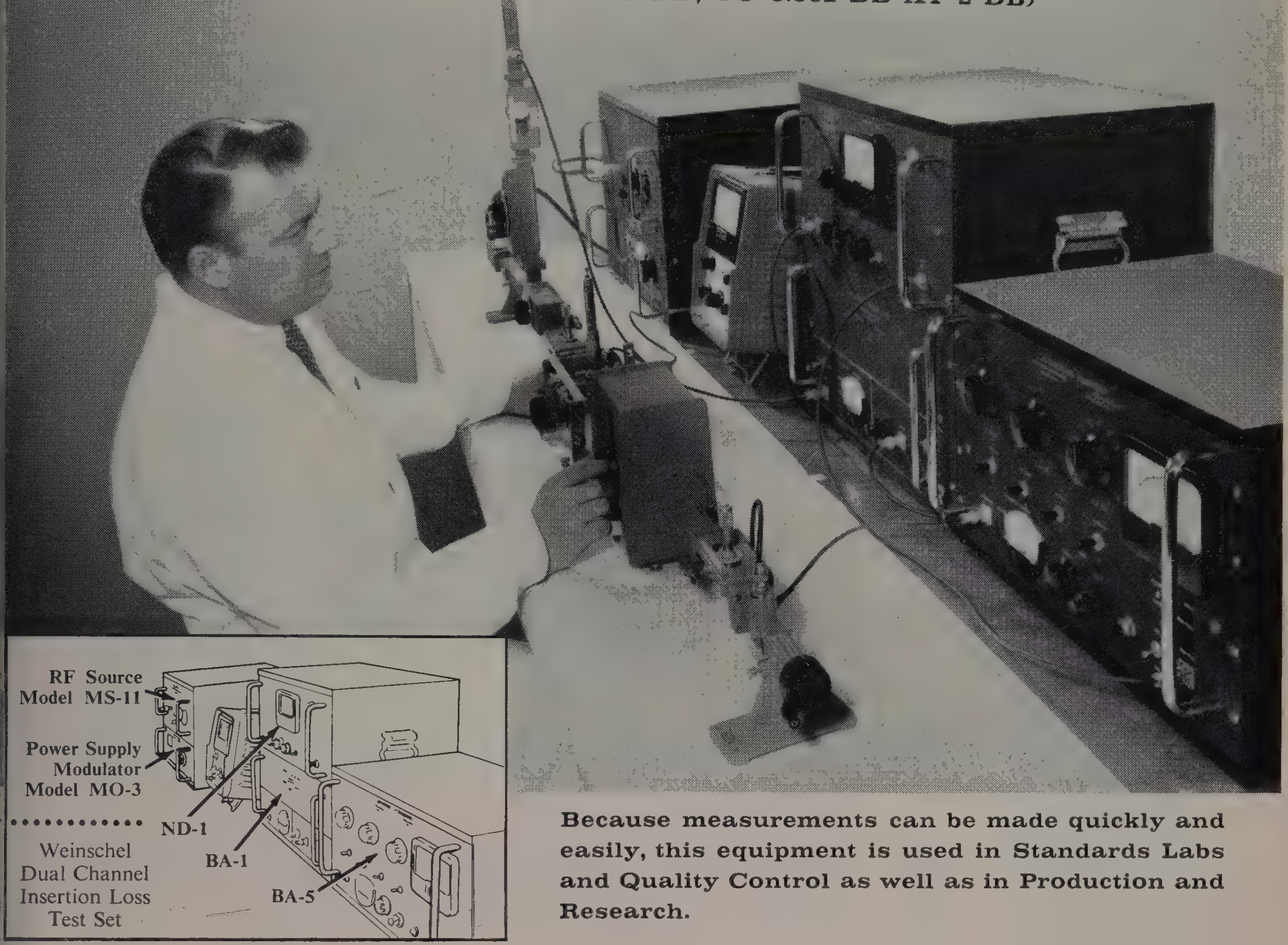
Applied Microwave Electronics, Inc., and the Washington Aluminum Company, both of Baltimore, Md., have announced a technical affiliation to provide "total mechanical and electronic capability for antenna systems."

Frederick N. Rushton, president of Washington Aluminum, said the pooling of technical talent and facilities between

(*Continued on page 49*)

ONLY THE DUAL CHANNEL TEST SET MEASURES SMALL RF ATTENUATION DIRECTLY

(PRECISE TO 0.01 DB AT 10 DB; TO 0.002 DB AT 2 DB)


RF Source Model MS-11
Power Supply Modulator Model MO-3
ND-1
BA-1
BA-5
Weinschel Dual Channel Insertion Loss Test Set

Because measurements can be made quickly and easily, this equipment is used in Standards Labs and Quality Control as well as in Production and Research.

This is the only direct reading equipment available for the precise measurement of small losses. It measures the "zero loss" of switches, cable assemblies, and waveguides. "Forward loss" of isolators, and loss and "wow" of rotary joints can be quickly determined. For losses below 2 db. the resolution is about 0.002 db.

The calibration of 50 DB X-band waveguide variable attenuators is one of the many applications of the more than 400 Weinschel Dual Channel Insertion Loss Test Sets now in use in laboratories, quality control departments and production lines all over the country. Test logs of individual customers show thousands of precise measurements with negligible down-time and maintenance.

SPECIFICATIONS:

Precision: 0.01 DB per 10 DB despite changes of 0.1 DB in level of RF source.

System Accuracy: 0.02 DB per 10 DB.

Attenuation Range: 20 DB direct.
40 DB with 20 milliwatt input and partial RF substitution.

Frequency Range: 20 MCS to 90,000 MCS.

The Instruments:
Model BA-1 Bolometer Preamplifier.
Model ND-1 Differential Null Detector.
Model BA-5 Attenuation Calibrator.

For theory, method, required instruments and recommended accessories, write for Weinschel Engineering Application Note No. 4.

WEINSCHEL ENGINEERING®

KENSINGTON, MARYLAND Phone: LOckwood 4-0121 TWX Kensington, Maryland 446

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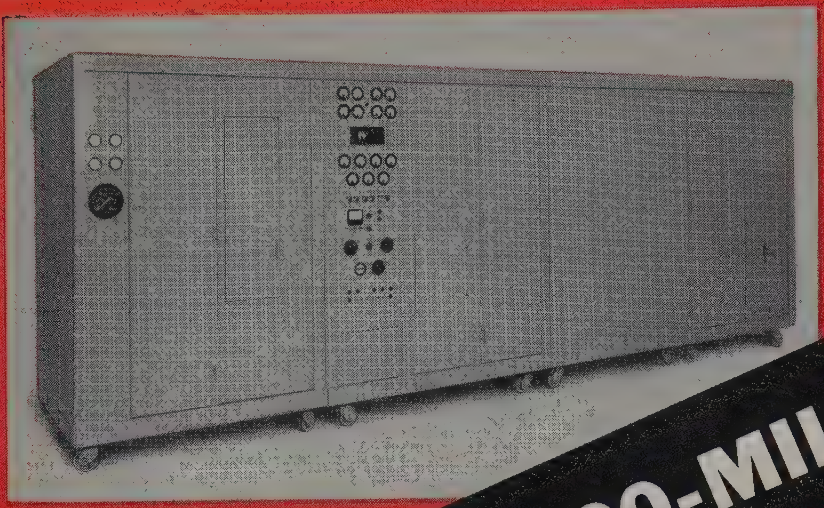
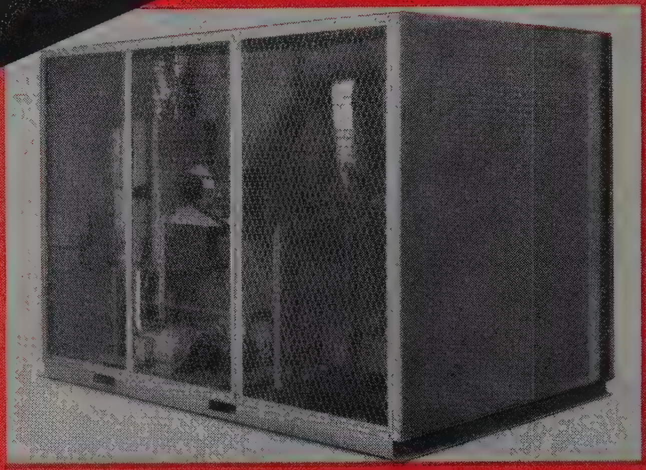
POWER FOR A 500-MILE TROPO HOP





These are views of the main power amplifier and heat exchanger—one of four sets of 75-kw troposcatter transmitters built to the exacting requirements of Air Force specification AN/FRC-39(V). Page Communications Engineers will install and operate them on the power-demanding 500-mile hop between England and northern Spain in the new Mediterranean communication network. Units utilize high-gain Varian klystrons to produce output directly with 5-watt drive; however, design permits use of similar Eimac tubes interchangeably. Sound like a Levinthal job? Well, it is, except that we've just changed our name to coordinate more suitably with our parent company. Now, it's Radiation at Stanford for high-power microwave packages.

Address us, for assistance with *your* problems, at 3180 Hanover St., Stanford Industrial Park, Palo Alto 7, California.

FORMERLY LEVINTHAL ELECTRONIC PRODUCTS INC.

RADIATION

Circle Reader Service Card 32

(*Continued from page 46*)

the two companies in specialized areas would make it possible to actively compete in the military electronics market for antenna systems contracts in radar, navigation, missile, and microwave communications programs.

J. Kelsey Burr, 3rd, president of Applied Microwave, added that the planned technical program would promote the manufacture and sale of precision standard microwave components. The marketing of the specialized hardware will be under the direction of Applied Microwave.

J. Gordon Neuberth, vice president and chief engineer of Applied Microwave, will direct the electronic design requirements, while Richard E. Thomas, manager of WACO's Special Productions Division, will direct and co-ordinate all mechanical designs and fabricational requirements.

—*mwj*—

1961 ELECTRONIC COMPONENTS CONFERENCE SET FOR MAY

The 1961 Electronic Components Conference, sponsored by AIEE, EIA, IRE and WEMA, will be held at the Jack Tarr Hotel, San Francisco, Cal., on May 2, 3 and 4.

Themes at the Conference will be: new components and their impact on engineering progress; new products and new requirements to meet the demands of our new engineering age; new techniques which make new components possible.

Mr. Hugh C. Ross, newly appointed Chairman of this Conference advises that subjects to be covered over the three-day period will include papers on components using magnetic principles; semi-conductors; microwave; high voltage components; Sw. Relays, Control Devices; Pulse Components; New Components for Power Generation; Space Components and Requirements; Reliability of Components; Capacitors, Resistors and Potentiometers; Super Cooled Components, Cryogenics; Hardware Plugs, Terminals, Printed Circuits, Wire, etc.; Filters; Microminiature Components; Optical, Magneto Optical and Light Sources; Instruments and Standard Measuring Devices; Vacuum Components and Equipment; Tubes other than Microwave and Data Processing Components.

The topics to be covered are not only of great interest and importance in the electronics industry but also in other industries where components problems are encountered.

For further information, contact Mr. Hugh C. Ross, Jennings Radio Mfg. Corp., P.O. Box 1278, San Jose 8, California.

—*mwj*—

LEHAN ELECTED EXECUTIVE VICE PRESIDENT

Frank W. Lehan has been elected executive vice president of Space Electronics Corp., Glendale, Cal. Since 1958 he has been vice president of the firm.

(*Continued on page 50*)

TRI-PLATE MODULE
MODEL MT16
SANDERS ASSOCIATES, INC.
MODEL MS4
MODEL MC11
MODEL MP12
TRI-PLATE MODULE
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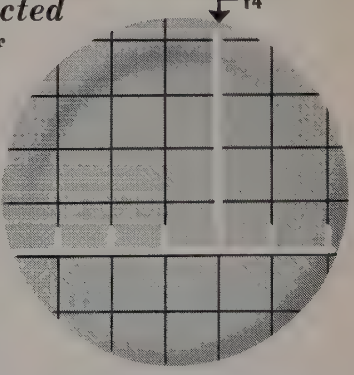

This power-level comparison of fundamental and harmonic frequencies shows the 4th harmonic 25% below input power . . . with the 1st, 2nd, 3rd, 5th, etc. suppressed.

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Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

Circle Reader Service Card 33

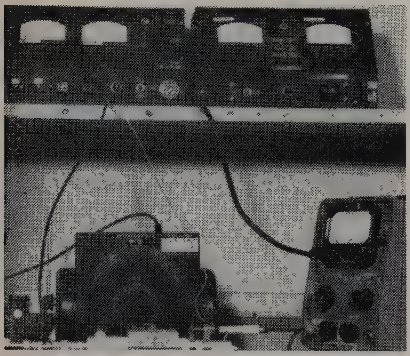
(*Continued from page 49*)

Previous to helping found SEC in 1958, Mr. Lehan served as associate director of the Electronics Laboratory at Space Technology Laboratories, Inc. He has also been chief of the Electronics Research section of the Jet Propulsion Laboratories where he pioneered the development of the FM/FM telemetry system.

Mr. Lehan was recently cited by the Institute of Radio Engineers for outstanding contributions in space electronics and telemetry. He is a senior member of that organization as well as belonging to the American Rocket Society, American Institute of Electrical Engineers and Sigma Xi.

— m w j —

PHILCO MADT TRANSISTOR ACHIEVES 5 KMC f_{max}



A laboratory prototype MADT transistor has been measured at 5000 megacycles, maximum frequency of oscillation, at Philco's Lansdale Division, Lansdale, Pa.

The prototype device was developed by semiconductor research engineers under the guidance of Dr. C. G. Thornton, director of R. & D. at the Lansdale Division.

Dr. Thornton explained that the MADT (Micro Alloy Diffused-base Transistor) exhibits a gain of 14 db at 1000 mc and 21 db at 420 mc, with noise figures of 8 db and 4 db respectively.

— m w j —

ZONNE NAMES FRIES GENERAL MANAGER

Raymond S. Fries has been named General Manager of the Ground Support Division of American Electronics, Inc., Los Angeles, Cal., according to Philip W. Zonne, president.

For the past 13 years, Fries has been with Minneapolis-Honeywell Regulator Company in responsible management assignments. During the last three years, prior to joining AEI, Fries was General Manager of Operations, Commercial and Military Division, which embraced plants in Wabash, Indiana, Chicago, Illinois, as well as Minneapolis, Minnesota.

Fries is a graduate of the University of Minnesota with a degree in Industrial Administration.

— m w j —

DOUGLAS MICROWAVE PURCHASES ELI-RON

The Douglas Microwave Co., Inc., Mount Vernon, N. Y., has purchased the Eli-Ron Electronics Company, Brooklyn, N. Y. Eli-Ron will be known as the Torotron Corp., a division of Douglas, with main offices and manufacturing facilities at 256 East 3rd Street, Mount Vernon.

Torotron will design and manufacture an expanded catalog line of toroidal components, magnetic amplifiers and related components, as well as wave filters, static inverters and high precision decade inductors.

Torotron will offer a complete line of toroids, featuring open, epoxy, and molded types, hermetically sealed in accordance with military specifications. Outstanding features include high "Q" characteristics (up to 350) with size and weight requirements compatible with the needs of space age airborne equipment. The newly enlarged company announced that it will also offer qualified engineering assistance in designing toroidal networks to customer specifications.

— m w j —

REEVES-HOFFMAN DIVISION PRESENTED RIQAP AWARD

The United States Army Signal Corps recently presented its "RIQAP" award to the Reeves-Hoffman Division of Dynamics Corp. of America, Carlisle, Pa., for "consistent production of high-quality quartz crystals over a long-term period."

"RIQAP," which stands for "Reduced Inspection Quality Assurance Plan," is the highest quality-recognition and honor the Army Signal Corps can bestow upon a manufacturer.

In ceremonies at the Reeves-Hoffman plant, Brigadier General Charles S. Hays, Commanding General of the U.S. Army Signal Supply Agency, (USASSA) presented the RIQAP certificate and then joined H. R. Potter, president of the Reeves-Hoffman Division, in raising the orange-and-white RIQAP "Q" for Quality flag. This is the second RIQAP flag-raising ceremony in which General Hays has participated and the first in Pennsylvania.

The Army Signal Supply Agency was also represented by Colonel F. J. Coffey, deputy for Quality Assurance; Mr. Arthur H. Haak, chief of Quality Assurance Operations Div., and Mr. Ted Di Renzo, public information officer.

"We congratulate you on the completion of five years of operation under the Army Signal Corps Reduced Inspection Quality Assurance Plan," said General Hays just before the RIQAP "Q" flag was raised into place. "The effectiveness of your program can be attributed to the fine spirit and cooperation which exists between men and management at your plant.

— m w j —

(*Continued on page 52*)

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Styroflex® Spirafil® Foamflex®

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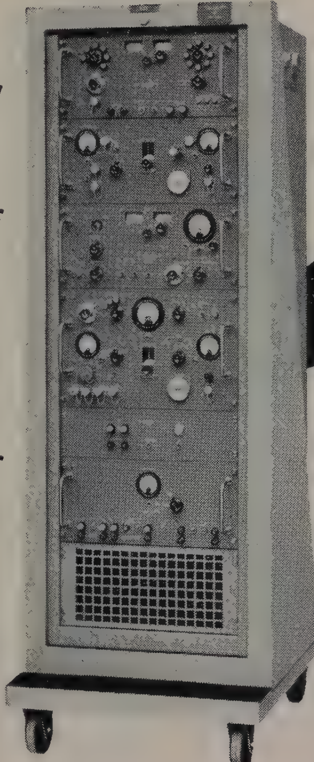
- *simulation of radar signals— in motion, static tests, doppler effects...*



The DY-5130, typical radar simulator system, speeds and simplifies factory and field test of cw-doppler radar equipment, simulates relative range, direction and velocity of target.

all made real and usable to meet any testing requirement

Dymec Radar Simulators evaluate operational readiness of missile and ground-based radar equipment by precisely duplicating signals encountered under actual operating conditions.

Through the use of serrodyne modulation techniques, Dymec provides stable test signals to monitor and maintain radar equipment. Frequency offset, simulating a doppler shift, is accomplished by applying a sawtooth voltage, precisely controlled in frequency, to a traveling wave tube helix. Clear spectrums with offsets of up to 500 KC are available. Dymec Radar Simulators provide the check-data you need **before the fact** of operation.

An efficient technique for increasing radar and communication range depends on coherent detection and employs extremely stable frequency sources. Dymec has developed both open and closed-loop frequency generation and stabilization circuits for testing such coherent systems.

Dymec offers versatile radar simulator systems made up of signal-generator/modulator assemblies using field-proved techniques developed by Hewlett-Packard. Application of these techniques by Dymec permits simulation to a high degree of accuracy of the many types and combinations of modulated signals produced by today's radar systems. Flexibility and high-performance are the standards ready to serve you today, whatever your requirement.

Describe your problem to your nearest Dymec/Hewlett-Packard representative or direct to Dymec.

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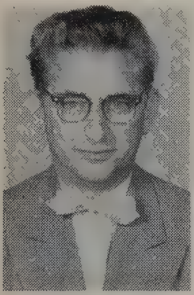
(Continued from page 50)

HUTTER NAMED CHIEF ENGINEER AT SYLVANIA



The appointment of Dr. Rudolph G. E. Hutter as chief engineer, Microwave Device Operations of the Electronic Tube Division of Sylvania Electric Products Inc., Mountain View, Cal., has been announced by W. Herbert Lamb, Vice President in charge of the division's Microwave Device and Picture Tube Operations.

In his new position, Dr. Hutter will be responsible for research, development and engineering activities of Microwave Device Operations in Mountain View and at Williamsport, Pa., as well as for technical coordination with the Palo Alto and Bayside, N. Y., Laboratories of General Telephone & Electronics Laboratories Inc.

Dr. Hutter joined Sylvania in 1944 as a senior engineer in the company's Research Laboratories at Bayside. Since that time he has held positions as section head in charge of microwave electronic research, engineering manager in charge of physical electronics development, manager of the Physics Laboratory, and associate director of research in physics.

— m w j —

DAUER JOINS STAFF OF AIRCRAFT ARMAMENTS

Aircraft Armaments, Inc., Cockeysville, Md., has announced the appointment of Dr. Maxwell Dauer as Principal Staff Scientist assigned to the company's Plans & Programs Division. In this capacity, Dr. Dauer will provide technical advice and assistance on current company projects and will review and evaluate new areas of scientific research and development.

Recently retired from the Medical Service Corps of the U. S. Army as a Lt. Colonel, Dr. Dauer holds four academic degrees. He received the AB and ScM degrees from New York University, the LLB degree from George Washington University, and the PhD degree from the University of Chicago. His primary specialty is radiation physics, including radioisotope applications and weapons effects. He has had extensive experience in the chemical, biological, radiological, and nuclear energy fields gained over a period of 20 years' military service, including assignments to the Manhattan Project and the U. S. Atomic Energy Commission.

— m w j —

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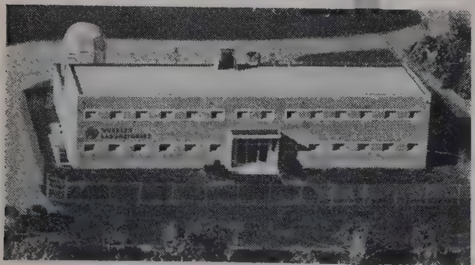
ON LONG ISLAND/A SUBSIDIARY OF HAZELTINE CORPORATION

Main Office and
Microwave Laboratory
Great Neck, New York

WHEELER LABORATORIES



Antenna Laboratory
and Test Range
Smithtown, New York

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

WL

HAROLD A. WHEELER
and Engineering Staff

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GRIGSBY APPOINTED DIRECTOR AT APPLIED TECHNOLOGY

The appointment of Dr. John L Grigsby to the board of Directors of Applied Technology, Inc., has been announced by Dr. William E. Ayer, president of the advanced electronic systems firm, Palo Alto, Cal.

Dr. Grigsby will continue in his present position as Chief Engineer, in which he is responsible for the direction of the company's expanding engineering activities in reconnaissance receiving systems active electronic countermeasures and special instrumentation for ionsphere and radio astronomy studies.

Previous to his association with Applied Technology, Inc., Dr. Grigsby was with the Applied Electronics Laboratory at Stanford University where he was engaged in research and development programs on electronic countermeasure systems.

— m w j —

NEW ELECTRONICS FIRM ORGANIZED

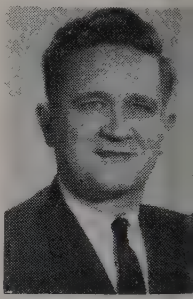
Advanced Development Laboratories, Inc., Nashua, N.H., has recently been organized to perform research, development, and manufacturing of radar and communication systems and microwave components.

The firm is presently outfitting a 10,000 sq. ft. leased facility on Haines Street Extension in Nashua. Members of the new firm have extensive background in the fields of phased array radars, CW and pulse doppler radars, active and semi-active missile guidance systems, antennas and stripline microwave devices.

The founders of the new Delaware Corporation are Kenneth Dollinger, president; Jesse L. Butler, secretary; Alfred J Cann, treasurer; and Martin E. Mehron director of system planning. Other members include Robert T. Malone, controller Victor A. Misek; William J. Wilson; and Roger Gilbody.

— m w j —

ROGERS WILL DIRECT MARKETING FOR MICROWAVE ELECTRONICS



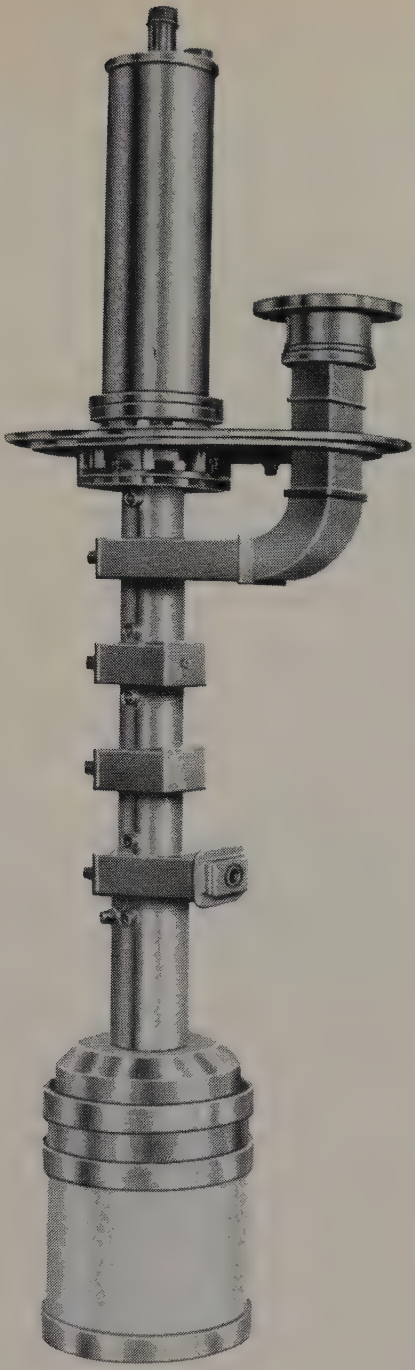
The appointment of Eugene L. Rogers as director of marketing for Microwave Electronics Corp., Palo Alto, Cal., has been announced by Dr. Stanley F. Kaisel, president.

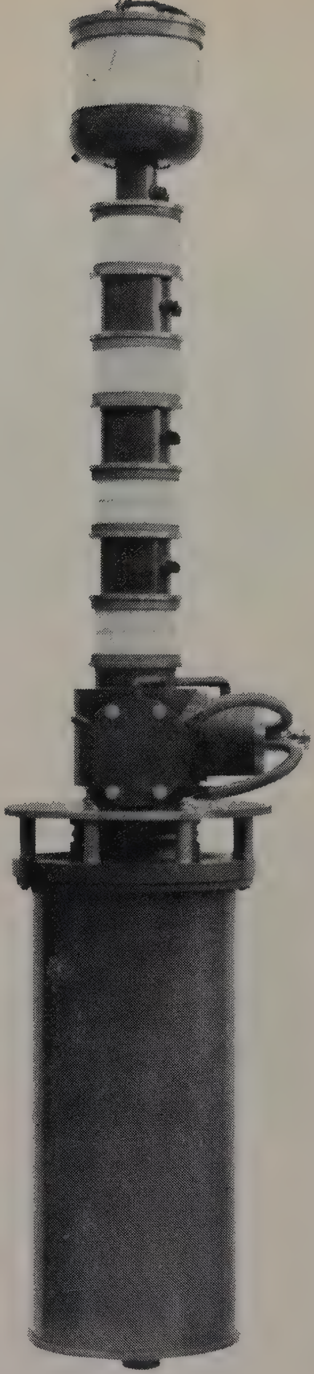
Since 1956 Rogers has been identified with the San Francisco Peninsula electronics scene, as director of marketing for the Instrumentation Division of Ampex Data Products Co. and for the Electron Tube Division of Litton Industries.

A native of Ohio, he graduated with BS in Electrical Engineering from Ohio Northern University and took a law degree from Georgetown University in 1951 He is a member of the bar of the District of Columbia and was admitted to practice before the U.S. Supreme Court in 1956.

— m w j —

(Continued on page 132)





There are 3 ways to design a klystron. Which is best?

The answer: there is no *one* best way. The design of a klystron must vary to meet specific performance requirements. For instance:

For the 4K50,000LQ, left, *external-cavity* design is best for producing 10 kw power output at 755-985 Mc. (Proof: more than 25,000 hours of near unattended service in troposcatter systems!)

For the 4KP40,000SQ, center, *internal-cavity* design is best for developing 10 Mw pulse output power at 2845-2865 Mc. (Proof: better than 2,500 hours in continuous rf service!)

For the 5K210,000LQ, right, a *combination* of internal and external design is best for achieving 75 kw minimum average power output at 755-985 Mc. (Proof: tested to 100 kw!)

Where will you find klystrons designed all three ways? Where will you find *every* klystron always shaped the best way to meet specific needs? *Only* at Eimac... where unmatched tube-making skills permit complete design flexibility. For more facts, more figures, get your free copy of "Advancing Klystron Performance Through Design Freedom." Write: Eitel-McCullough, Inc., San Carlos, California.

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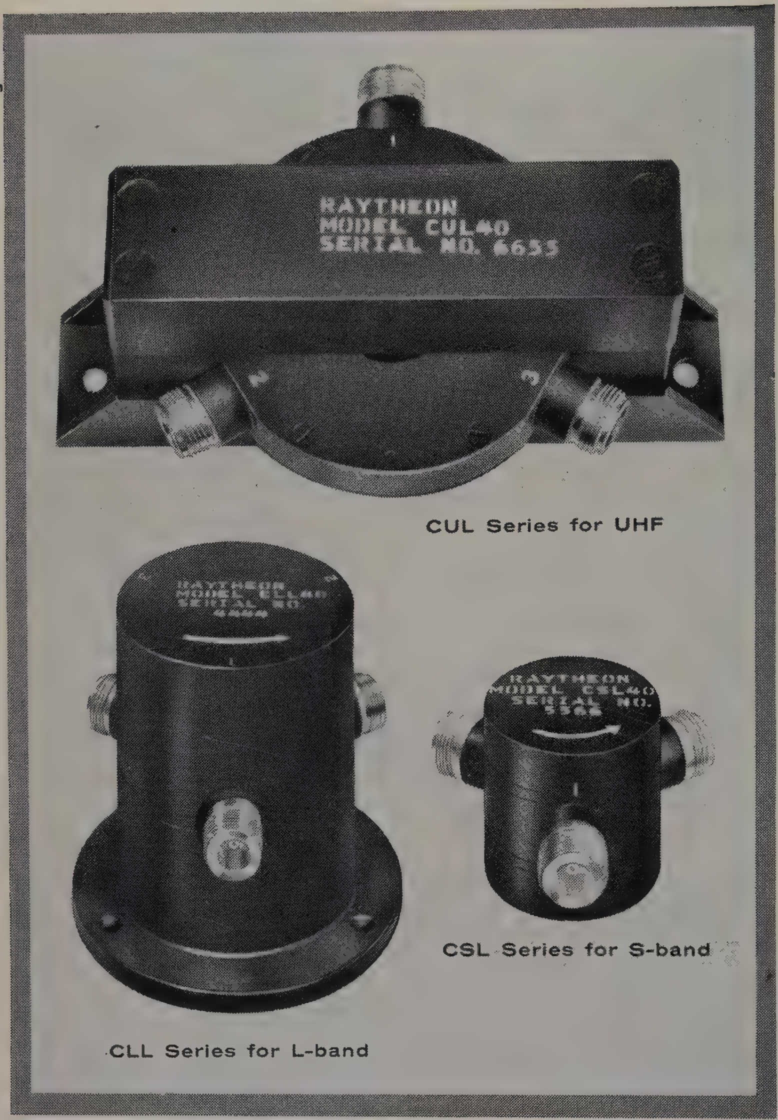

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The L- and S-band units—in production just 1
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ferrite circulator to the microwave industry—ca
be mounted directly to steel structural member
without any separation or shielding. Maximu
dimensions are 1¾ inches for S-band, 4 inche
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combination of any two of the units can be packaged for a highly efficient 4-port circulator.

To learn more about these significant developments and other circulators now available dow
to 400 Mc and up to 6000 Mc with similar characteristics, please write, stating your particula
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Raytheon Company, Special Microwave Devic
Operations, Waltham Industrial Park, Waltha
54, Massachusetts. In Canada, contact Raytheo
Canada Limited, Waterloo, Ontario.

TYPICAL SPECIFICATIONS OF MINIATURIZED CIRCULATORS

	UHF BAND CUL SERIES	L-BAND CLL SERIES		S-BAND CSL SERIES
Frequency Range	800-1000 Mc	1000-1700 Mc	1700-2400 Mc	2400-4000 Mc
Bandwidth	Any 10% band	Any 10% band	Any 10% band	Any 10% band
Isolation	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.
Insertion Loss	0.3 db min. 0.5 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.
VSWR	1.25 max.	1.25 max.	1.25 max.	1.25 max.
Power (Average)	5 watts	5 watts	5 watts	5 watts
Power (peak)	5 kw[2]	5 kw[2]	5 kw	5 kw
Weight (max.)	4.8 lbs.	3.3 lbs.	2.3 lbs.	11 oz.
Diameter (max.)[1]	6⅛ in.	2½ in.	2½ in.	1¾ in.
Height	3¼ in.	4 in.	2½ in.	1⅝ in.
Connectors	Type N	Type N	Type N	Type N
Temperature Range[3]	T_0 ±20°C	T_0 ±20°C	−40°C to +60°C	−40°C to +60°C

[1] Excluding Connectors

[2] Up to 100 kw is possible with Type HN connectors

[3] T_0 is 25°C unless otherwise requested

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SPECIAL MICROWAVE DEVICE OPERATION

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CONTRIBUTORS IN THIS ISSUE

TORE N. ANDERSON, born in Vasteras, Sweden, received his Electrical Engineering degree from the Cooper Union.

In 1948 Mr. Anderson started with Airtron, Inc., became Chief Engineer 1951, Vice President 1953, and Director of Engineering 1956.

Mr. Anderson is now a Microwave Consultant, having served for one year with FXR, Inc., in an executive capacity. He is also a consultant to the Department of Defense, Advisory Group on Electronic Parts. He is chairman of the EIA Committee TR21.1.1 on waveguide flange standardization, and the U. S. delegate to the International Electrotechnical Commission on international waveguide standardization. He is presently Vice Chairman of the PGMTT, a member of Tau Beta Pi, the American Physical Society and AIEE. Mr. Anderson is an editorial associate on *the microwave journal* and "the solid state journal."

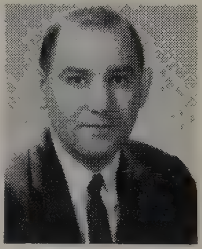
CARL BLAKE joined the staff of Lincoln Laboratory in July of 1957, where he is engaged in research on low noise devices.

During the period from 1949 to 1957, he served as an Assistant Professor in the Electrical Engineering Department at the University of Maine. He also did consulting work and was a registered Professional Engineer in the State of Maine.

Mr. Blake attended the Massachusetts Institute of Technology where he received his BS and MS degrees in 1949. He is a member of the IRE, PGMTT, PGCT, and Eta Kappa Nu.

ALBERT COHEN was born on October 14, 1927, in Boston, Mass. He received the BS degree in Electrical Engineering in February 1952, from the Massachusetts Institute of Technology. From 1952 to 1955, he was a senior research engineer at the Gabriel Laboratories where his activities were concerned with antenna and microwave component development in the broad spectrum of frequency from UHF through K_a band. He joined Lincoln Laboratory at the Massachusetts Institute of Technology as a staff member in 1955.

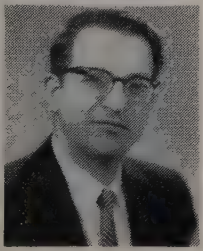
Mr. Cohen is a registered Professional Engineer in the state of Massachusetts, is concurrently pursuing the MS degree in Engineering Management at Northeastern University, and is a Senior Member of the IRE.



LEONARD I. KENT is vice president of Engineering and a member of the Board of Directors of the newly formed Microwave Semiconductor & Instruments Inc., of Richmond Hill, N. Y. Recently he has been engaged in microwave consultation.

Mr. Kent previously was Director of Engineering for Narda Microwave Corporation, and a Senior Project Engineer for the FXR Machine Works.

Mr. Kent graduated from Cooper Union School of Engineering with a BS Degree in Electrical Engineering. Also awarded a MS degree in Electrical Engineering, he currently is working for his Doctor's Degree. He is a member of the New Types Waveguide Sub-committee and the committee on Waveguides and Fitting of the Electronics Industries Association, and the Transducer Committee of the Instrument Society of America.



ANTHONY W. MALTESE was born on September 18, 1928 in Boston, Mass. He received a BS degree in Chemical Engineering from Northeastern University in 1951. In addition, he has taken a number of courses in Mathematics and Electrical Engineering at the Evening Engineering Graduate School at Northeastern.

He has been on the engineering staff of the Tileston and Hollingsworth Company and with the Gabriel Electronics Division of the Gabriel Company. His activities with the latter concern have included the design of microwave antennas and components. Since 1957 he has been a staff member at Lincoln Laboratory, engaged in the design and evaluation of ground rigid radomes and also assisted in the design of the Laboratory Antenna Test Range.

ELLIS P. McCURLEY was born in Medford, Oregon on November 12, 1925. He received a BS degree in general engineering from the U. S. Naval Academy in 1946, a BA degree in physics from Reed College in 1952, and a MS degree in physics from the University of Wisconsin in 1954.

In 1954 he joined the Lincoln Laboratory of MIT, where he is presently a member of the Microwave Components Group working on parametric amplifiers.

Mr. McCurley is a member of Phi Beta Kappa and the IRE.

GERSHON J. WHEELER heads Solid State Device Development at Sylvania Electric Products, Inc., Microwave Device Operations. He engages in the design and development of ferrite devices, parametric amplifiers, and solid state microwave components.

Mr. Wheeler previously worked at Raytheon Manufacturing Co. (1950-1957) and as an Instructor in Mathematics at Northeastern University (1955-1957).

Mr. Wheeler has been in the field of microwave electronics since 1942. In addition to being a senior member of the IRE and member of RESA, Mr. Wheeler is an editorial specialist for *the microwave journal* and "the solid state journal."

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If you have TWT headaches—finding a microwave amplifier *now*—which produces high gain and wide bandwidth *with* high average and peak powers—Hughes may have just the prescription for you. Hughes TWT's provide all these desirable features with built-in long life, ruggedness and dependability. They fully exploit the advantages of permanent magnet periodic focusing in both glass and metal-ceramic structures, and many are available in either gridded or ungridded versions.

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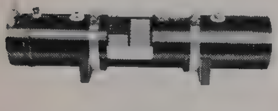
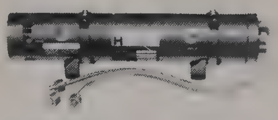
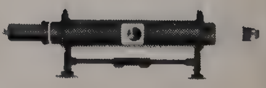


311H 2.0-4.0 KMC Gridded 1 KW minimum peak power output, 1% duty, 36db small signal gain @ 50 mw input. Weight 13 lbs. Length 17-7/16".



312H 2.0-4.0 KMC Gridded 1 KW minimum peak power output, 1/2% duty, 36db small signal gain @ 50 mw input. Weight: 11 lbs. Length: 15-3/8".

304H 2.0-4.0 KMC Ungridded, 1 KW minimum peak power output, 1% duty, 37db small signal gain @ 1 mw input. Weight: 12-1/2 lbs. Length: 17-31/32".



307H 8.5-9.5 KMC 50 KW minimum pea power output (500 watt average), meta ceramic construction, 54db saturatio gain, 1% maximum duty cycle, bea voltage = 38 kv. Wt. 21 lbs. Length: 24-

Hughes also has a complete line of K_u-band backward-wave oscillators for commercial and military application
Write or telephone today for full information or a catalogue concerning the broad line of Hughes TWT's available in L, S, C & X bands.
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THE LINCOLN LABORATORY ANTENNA TEST RANGE

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Introduction

A new Antenna Test Range employing ground level techniques and introducing a number of innovations resulting in substantial economic, engineering and operating advantages has been completed. It consists of four measuring stations, three of which have a transmission distance of 2,000 feet (the long range) and the fourth, a transmission distance of 720 feet (the short range). The ground level range paths have been graded to within ±1 inch of a true plane. Instrumentation and equipment have been provided for the measurement of the radiation characteristics of antennas having apertures up to 30 feet over the continuous frequency band from 250 Mcps to 2,000 Mcps (the short range), and for apertures up to 10 feet over the continuous frequency band from 2,000 to 16,000 Mcps (the long range). All the transmitter station functions are remotely controlled from a centralized area located in the receiver building. The receiver building consists of three 20 foot x 20 foot x 20 foot test cubicles covered on five sides with microwave absorbing material, an equipment control room and general laboratory space. These test cubicles, in conjunction with the remotely controlled and fully enclosed transmitter stations, provide essentially continuous, interference-free operation, uninterrupted by inclement weather conditions. In addition, instrumentation and equipment have been provided for the precise measurement of model antenna-radome characteristics.

Design Considerations

The far-field radiation characteristics of an antenna can be determined by illuminating the antenna from a fixed transmitting source, and thereafter detecting and recording the energy received at the antenna terminals as a function of the orientation of the antenna under test with respect to the transmitting source.[1,2] The transmitter should be located sufficiently remote so that essentially a uniform phase and amplitude distribution is obtained at the test antenna aperture. For a circular aperture this requirement is approximated when:[3]

$$R = \frac{2D^2}{\lambda}\,, \tag{1}$$

where

R = distance between the transmitting and receiving antennas where the latter is the antenna under test.

D = test antenna aperture which should be equal to or greater than the transmitting antenna aperture.

λ = test wavelength.

Figures 1 and 2 show the maximum antenna apertures that satisfy Equation (1) for the range distances of concern here.

This distance criterion results in a phase difference of $\pm \lambda/16$ at the extremities of the test antenna aperture. It should be noted that techniques of defocusing for paraboloidal antennas can be applied to increase the effective length of a test range[4,5], which essentially adds versatility to any facility. We shall not enter into that discussion here except to point out that the distance criterion of Equation (1) does not necessarily represent

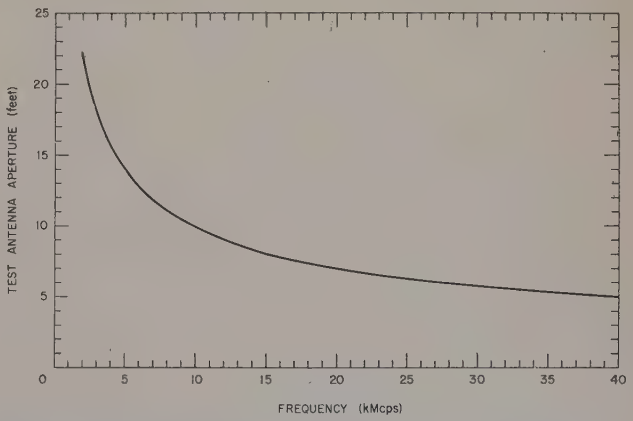

Figure 1 — Maximum test antenna size using $2D^2/\lambda$ criterion for a 2000 foot transmission distance (long range).

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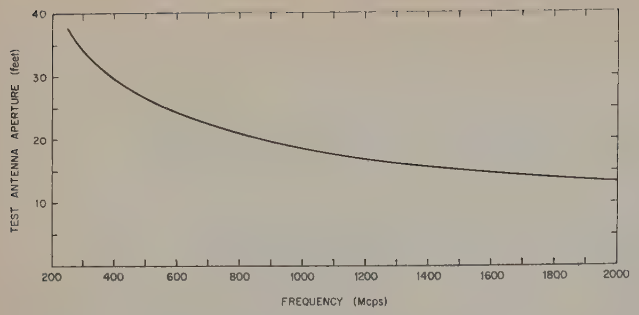


Figure 2 — Maximum test antenna size using $2D^2/\lambda$ criterion for a 720 foot transmission distance (short range).

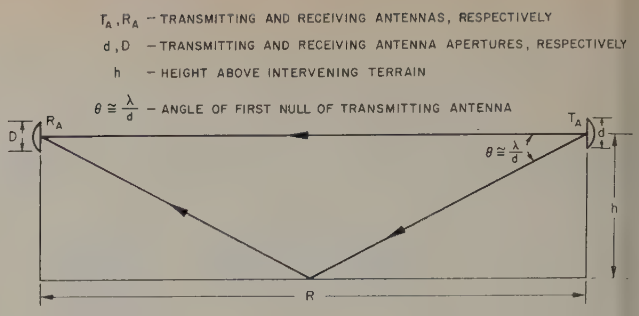

T_A, R_A — TRANSMITTING AND RECEIVING ANTENNAS, RESPECTIVELY
d, D — TRANSMITTING AND RECEIVING ANTENNA APERTURES, RESPECTIVELY
h — HEIGHT ABOVE INTERVENING TERRAIN
$\theta \cong \frac{\lambda}{d}$ — ANGLE OF FIRST NULL OF TRANSMITTING ANTENNA
D
R_A
T_A
d
$\theta \cong \frac{\lambda}{d}$
h
R

Figure 3 — Representation of high level test range design.

a fixed bound. With only very slight modifications to the measured test antenna patterns, effective distances may be increased by a factor of 10 or more over that given by Equation (1).

In addition to the distance criterion, the antenna heights must be such that reflections from the transmission path are either minimized or can be controlled. Generally, in previous test range designs, use was made of the so-called "high-level" techniques. In the high level application, efforts are primarily directed toward minimizing as compared to controlling, reflections from the intervening terrain between the transmitting site and the receiving antenna under test. With reference to Figure 3, which depicts two hills or towers with intervening valley, some general comments on this type of test range are appropriate.

The high-level design technique employs the use of a directional transmitting antenna, such that the height, range distance, and transmitting antenna aperture are compatible. For this compatibility to exist, it is desirable to choose the transmitting antenna aperture, at the operating wavelength, in conjunction with the usually fixed parameters of height and range distance, such that the first null of the transmitter pattern is oriented along the direction of the point of spectral reflection. The angle of the first null of the transmitting antenna is given approximately by $\frac{\lambda}{d}$[3], where "d" is the largest aperture dimension of this antenna. From Figure 3, one can see that for reasonably small beamwidth transmitting antennas:

$$\frac{\lambda}{d} \cong \frac{2h}{R}\text{; or } h \cong \frac{\lambda R}{2d}\,. \qquad (2)$$

Equations 1 and 2 then correlate the parameters of height, range distance, test and transmitting source antenna apertures and frequency of operation. Inspection, however, reveals several undesirable limitations. For example, one generally does not possess control of the intervening terrain between transmitter and receiver, and the implied assumption of a relatively flat area of spectral reflection cannot be justified. The intervening terrain will in general be far from level and will contain such irregularities as trees, underbrush, houses, and roads over which moving vehicles may pass. In addition, it will be observed from Equation (2) that, in order to maintain the quality of the incident phase front on the test antenna as the test frequency changes, the ratio of the operating wavelength to the transmitting antenna aperture should be kept constant. This assumes, as is generally true with this type of facility, that the heights of the transmitter and receiving antennas are fixed by the terrain (hills and towers) and that the range distance is not variable. If, then, this implied quality is to be adhered to, a serious bandwidth problem arises; i.e., for each change in operating frequency an appropriately large transmitter source antenna need be installed. In the actual case, one generally designs with a lower frequency limit in mind and accepts the effects of spectral reflection of the transmitting antenna side lobes as the frequency increases. Thus, in addition to the bandwidth limitation, i.e., necessity of changing transmitting antennas as the operating frequency changes, the quality of the incident plane wave is constantly in doubt. Furthermore, measurement and set up time may be long and laborious. Other inconveniences also exist with the "high level-separated terminal" type facility, such as constant exposure to the weather elements and stray interference which increases the "down-time" of the test range, in conjunction with difficulty in remotely controlling the transmitter station functions, all of which decreases efficiency. This latter situation generally arises due to the lack of control or ownership of the intervening terrain between the separated test terminals.

In place of the usual technique, described above, of determining antenna characteristics by placing the test antenna high above the ground in order to simulate free-space conditions and minimize ground effects, the Lincoln Laboratory facility employs "ground-level" techniques. Here, the antennas and measuring equipment are located proximate to ground level and the concept of minimizing reflections (as in high-level types) gives way to controlling and utilizing the ground reflections. With reference to Figure 4, if the surface of the terrain between the transmitting and receiving antennas is sufficiently flat, the energy arriving at the test antenna is composed of a direct ray from the transmitting antenna and an indirect or ground-reflected ray. The direct and ground-reflected rays combine to produce a well-defined interference pattern at the test antenna aperture. Under these conditions, the amplitude distribution of this interference pattern is dependent upon the wavelength of the transmitted energy as well as the height of, and distance between, the transmitting and test antennas.

Consider the case indicated in Figure 4 of a flat ground plane of length R and transmitting and receiving antenna heights, h_T and h_R respectively. When the transmitting antenna is located proximate to the flat ground plane so that the grazing angle of the reflected ray is small ($<2°$), then the magnitude and phase of the reflection coefficients are very nearly unity and 180° respectively, relative to the direct ray for both horizontal and vertical polarization.[6] The resultant spatial energy dis-

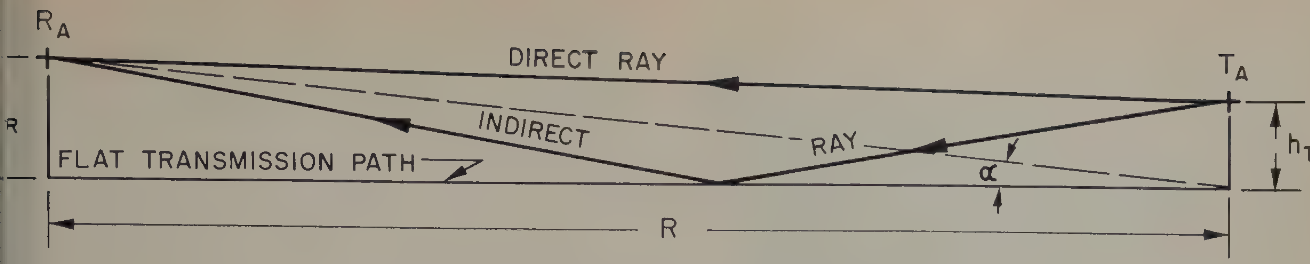


Figure 4 — Representation of ground level test range design.

ution can then be obtained by utilizing the image
nciple. The procedure is to replace the ground plane
an image source, compute the array pattern of two
int sources of equal magnitude, out of phase 180° and
arated by twice the height between the transmitting
enna and ground. The final step is to multiply this
nputed array factor by the element factor, which in our
e, is the transmitting antenna pattern. The field
ength in the far field, as a function of elevation angle α
then given by:

$$E(\alpha) = E_o F(\alpha)\ \mathrm{Sin}\ \frac{2\pi h_T}{\lambda}\ \mathrm{Sin}\ \alpha. \qquad (3)$$

Where F (α) is the elevation pattern of the trans-
tting antenna — commonly referred to as the element
tor. Generally the beamwidth of the element factor
large compared to the beamwidth of the array factor,
d thus F (α) may be taken as unity or constant over
e elevation angles of interest.

For the conditions cited above and of interest here, i.e.,
small grazing angles and small elevation angles,

$$n\ \alpha \cong \tan \alpha \cong \frac{h_R}{R}\ .$$

bstitution in Equation (3) yields:

$$E(h_R) \cong E_o\ \mathrm{Sin}\frac{2\pi h_T\ h_R}{\lambda R}\ , \qquad (4)$$

here

h_T and h_R are the antenna heights above ground,
R is the range distance,
λ is the wavelength of operation,
d E_o is a constant.

Solution of Equation (3) gives a multilobed structure,
e number of lobes being dependent upon the wave-
ngth and transmitter height above ground. The first
be of this interference pattern is of primary concern in
e case under discussion since it can be used to illumi-
ate a test antenna, the center of the aperture under test
eing located at the point of maximum field intensity of
is first lobe. It should be noted that for this case the
ansmitted energy incident on the antenna under test
pears to emanate from the phase center of the trans-
itting antenna and image combination. This phase cen-
r is coincident with the ground level at the base of the
ansmitter, and, for all intents and purposes, the ground
ane is of no further concern.

We have seen, thus far, that the antenna under test is
uminated by the transmission emanating from a ground
vel point at the transmitter. The energy thus transmit-
d has an elevation beamwidth essentially equal to the beamwidth of the first lobe of the array factor. (It should be noted that the horizontal beamwidth of this illuminating pattern is determined by the beamwidth of the element factor and results in a uniform horizontal distribution at the test antenna aperture). For the condition that the antenna under test be positioned at the peak of the first lobe of the interference illuminating pattern, Equation (4) reduces to

$$h_R = \frac{\lambda R}{4h_T}\ . \qquad (5)$$

It may now be observed that if the ratio of $\frac{\lambda}{h_T}$ can be made a constant, i.e., as the frequency of operation changes, h_T can be adjusted such that the ratio remains constant, and for a fixed transmission distance R and test antenna height h_R, the illumination pattern of the transmitting source is essentially independent of the transmiting antenna aperture and wavelength of operation.

These conditions are easily met, since the beamwidth of the element factor which multiplies the array factor is generally several times the beamwidth of the interference pattern. Further, adjusting h_T so as to keep $\frac{\lambda}{h_T}$ a constant as the frequency changes, is facilitated by proximity to ground, since all that is required is an adjustable height stand. Therefore, with the aid of broadband transmitters and transmitting antennas (element factors only), continuous frequency coverage and consistent quality of operation may be obtained.

The Lincoln Laboratory test range is designed to make use of the concepts outlined above. The distance between the transmitting and test antennas is fixed, although it should be clear that the capability of changing or varying this distance is in hand when one controls the intervening terrain. This condition also simplifies remote control operation of the transmitting stations, since an electrical cable run along the side of the transmission path is all that is required to facilitate this control. For any selected operating frequency, the heights of the receiving and illuminating antennas are adjusted to fulfill the conditions given above in Equation (5). For example, for a transmission path whose length R=2,000 feet, an X-band operating wavelength of 1 inch (1/12 foot), and a receiving antenna height $h_R = 10$ feet, the height of the transmitting antenna is adjusted to $h_T = (1/12 \times 2{,}000)\ (4 \times 10) = 4.2$ feet in order for the receiving antenna to be positioned at the peak or maximum value of the interference pattern. For such conditions, the receiving antenna aperture is essentially uniformly illuminated so that conditions like those of free-space are simulated.

General Features

To make practical use of the principles outlined above, an unusual arrangement of test facilities is obviously required. The Lincoln Laboratory antenna facility consists of five major units: (1) a receiver building containing four test positions as well as all instrumentation and remote controls; (2) a transmitter building housing three antennas, each with an RF source operating from 2-4, 4-7.6, 7-11 or 8-16 kMcps; (3) a transmitter tower, containing an antenna and RF energy sources for operation between 0.25 and 2 kMcps; (4) a short-range or ground level transmission path for measurement of antennas up to 30 feet in size over the frequency range between 0.25 and 2 kMcps; and (5) a long-range or ground-level transmission path, for measurement of microwave antennas and radome characteristics between 2 and 16 kMcps.

All measurements are made at the receiver building. Data can be taken simultaneously on three antennas, and automatic recording equipment permits antenna patterns to be traced in about half a minute for a given set of conditions. Measurement conditions may be quickly and easily changed by remote controls in the receiver building. Remote control permits desired adjustments to be made of the frequency and polarization of the low-power RF energy transmitted, of the position, height and direction of the receiving and transmitting antennas, and of orientation of radomes about the test antenna when radome measurements are being made. Because transmitting and test antennas are in fixed positions, and because all instrumentation and remote controls (as well as the transmitting antennas for the long range) are housed in permanent buildings, it is possible to make reproducible measurements, independent of weather conditions. We shall also see that proximity to ground facilitates the employment of microwave test cubicles capable of housing the test antennas.

Ground-Level Test Ranges

The need for ground-level surfaces that are as flat as possible may be inferred from the description of the mode of operation of the Lincoln Laboratory facility. Of interest then, in a site survey, were land areas that were relatively level so that the cost of site preparation would be kept low. Over-water sites were considered but ruled out since operation in the millimeter wavelength region would not be possible when wind velocities exceeded approximately 10 m.p.h.[7] The area finally chosen was a 54 acre tract of land located on South Road in Bedford, Mass., approximately two miles from Lincoln Laboratory. A topographical survey and soil samples of this area indicated that suitable transmission paths could be prepared. The requirement imposed was that these surfaces remain smooth planes within a vertical tolerance of ± one inch under all operating conditions. This tolerance was established based on ground reflection studies conducted by the University of Texas[8] and at the Bell Telephone Laboratory Test Range at Whippany, N.J.[9]

To insure that the ranges would remain plane to the required tolerances, very careful preparation of the topsoil and subsurface was required. The sequence of preparation was (1) clearing and grubbing, (2) stripping the loam from the area and storing, (3) filling and rough grading, (4) construction of drainage facilities, (5) construction of the cable trenches which house the cable for the remote operation of various transmitter functions (6) soil compaction, (7) spreading, rolling, and fin grading the top soil course. When grading was completed both ranges were seeded with Kentucky Blue and othe high grades of grass to maintain the surface. Adequat soil engineering and survey controls were established t insure that the required surfaces were obtained and would be maintained. The three factors which could contribut to surface distortion are (1) settlement, (2) surface wea and (3) frost effects.

The control of settlement required that soft, compressible foundation materials be removed and replaced wit clean sand backfill. The base course soils had to be non frost susceptible and well drained. This required that a upper limit be placed on the amount of soil fines tolerable. At the same time, the base course soils had t possess good compaction characteristics. This require that they be well sorted and contain some fines for binding action.

Surface wear required the establishment of a good tur to minimize erosion and to provide stability of the surface under light vehicle traffic as required for mowing and periodic maintenance. Since the top soils availabl were considered potentially frost susceptible, care wa taken in the selection and placement of the underlying base material.

The third factor which could contribute to surface distortion is the vertical rise of a soil mass owing to th penetration of freezing temperatures into the soil and th freezing of the soil water, and the type of soil. The surface of any water-filled soil mass will rise when frozen The amount of rise is drastically reduced as the averag saturation is diminished and the water in the voids i allowed space in which to expand without displacing th soil. There is another type of frost response recognize in practice and known as frost heave. Ice formation i this case assumes a layered appearance, alternating wit layers of soil. Water to feed the growth of these "ice lenses" is impelled to move upward to the zone of freezing by suction forces generated at the ice front. Since th ice front remains approximately stationary, growth is accomplished by the upper displacement of the overlyin frozen soil. The hydraulic and thermodynamic condition that support this action will not be discussed here. Th two main methods of controlling detrimental frost heav are (1) to use non-frost-susceptible materials and (2 tolerate the presence of frost-susceptible soil but deny i access to a supply of water. Since the top soils are considered potentially frost-susceptible, the second metho

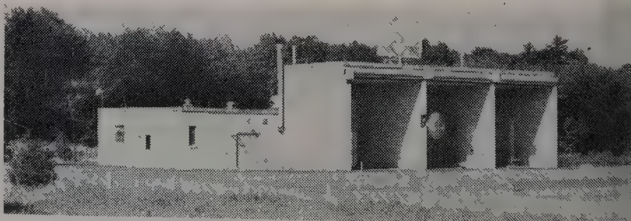


Figure 5 — General view of the receiver building. The lowe portion of the building contains the office, dark room, utilit room, laboratory, and equipment control room. The talle structure houses the three receiving stations, shown wit the metal roll-up doors in the open position. In the background is seen a four element helical array being tested o the short range station.

s used to control the frost heave. The base course pth and grain size were adjusted such that the height of capillary rise of the soil above the water table is s than the distance from the water table to the top of e layer. This insured that the top soil course would be ectively isolated from the water table.

ceiver Building

The receiver building, a one-story structure of cinder ock and steel construction, is shown in Figure 5. It ntains an office, a machine shop, a utility room, a labor- ory area, a room to be fitted as a free space area or echoic chamber (commonly referred to as a "dark- om"), an equipment control room, and three cubicles r housing the test antennas which use the long range. fourth antenna can be located on the roof for testing on e short range.

The three cubicles or receiving stations, each 20 x 20 x feet in size, are designed for operation from 2 to 40 lcps, and are covered on five sides with microwave ab- bing material approximately 4 inches thick. The ma- ial used has an impedance essentially that of free space d provides 30 to 40 db of attenuation. As shown in Fig- e 6 the absorbing material on the rear wall of the receiv- g cubicles is in the form of equilateral triangular prisms out 2 feet on each face and extending from floor to ling. All absorbing material on the floor, the ceiling, d the remaining two sides is fastened flat against the ll. The front wall of each cubicle, looking toward the nsmitter building 2,000 feet down the range, contains metal "roll-up" door which is opened when tests are ing made. The test antenna is then exposed to the am from an antenna in the transmitter building at the r end of the range; energy which is not captured by the ceiving antenna is dissipated in the microwave absorb- g material.

For orienting the receiving antenna, each receiving bicle contains a heavy duty azimuth antenna positioner ving a turntable diameter of 8 feet mounted in a con- ete pit so that the turntable top is at the floor level of e cubicle. Jack screws are located between the posi- oner mounting pads and the pit floor so that the rota- onal axis is perpendicular to the line of sight between e test antenna and the effective center of radiation of e transmitting antenna. The center long-range station ntains a two-axis radome positioner and precision an- nna positioner which is used for boresight evaluation. igure 7 shows these positioners in place on its azimuth tator. The other two long-range stations contain polari- ation and elevation antenna positioners, making possi- le automatic recordings of the principal plane patterns any desired polarization of the receiving antenna under st.

Four wide range superheterodyne receivers are pro- ided. Two cover the range of 2 to 75 kMcps, and a third ne operates from 30 Mcps to 75 kMcps. The fourth re- eiver has provision for simultaneously amplifying four F signals and covers the range from 2 to 75 kMcps. The igh gain receivers, which permit RF energy sources to e of low power, employ swept local oscillators which irtually eliminate the effects of any shift that may occur n transmitter frequency.

Consoles, which are located in the equipment control oom of the receiver building contain all the necessary

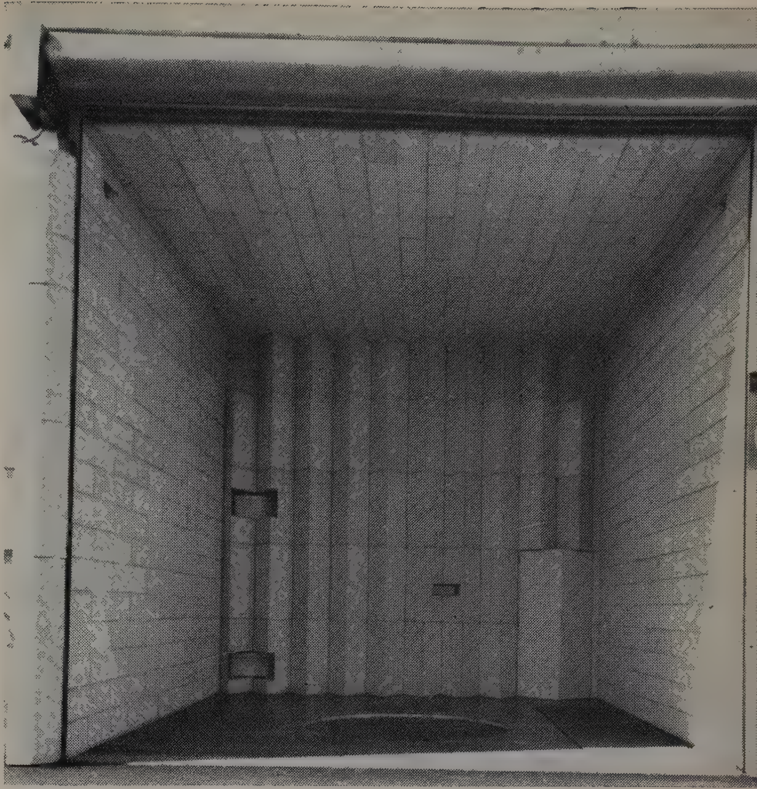


Figure 6 — Interior view of a receiving station showing installation of absorbing panel material.

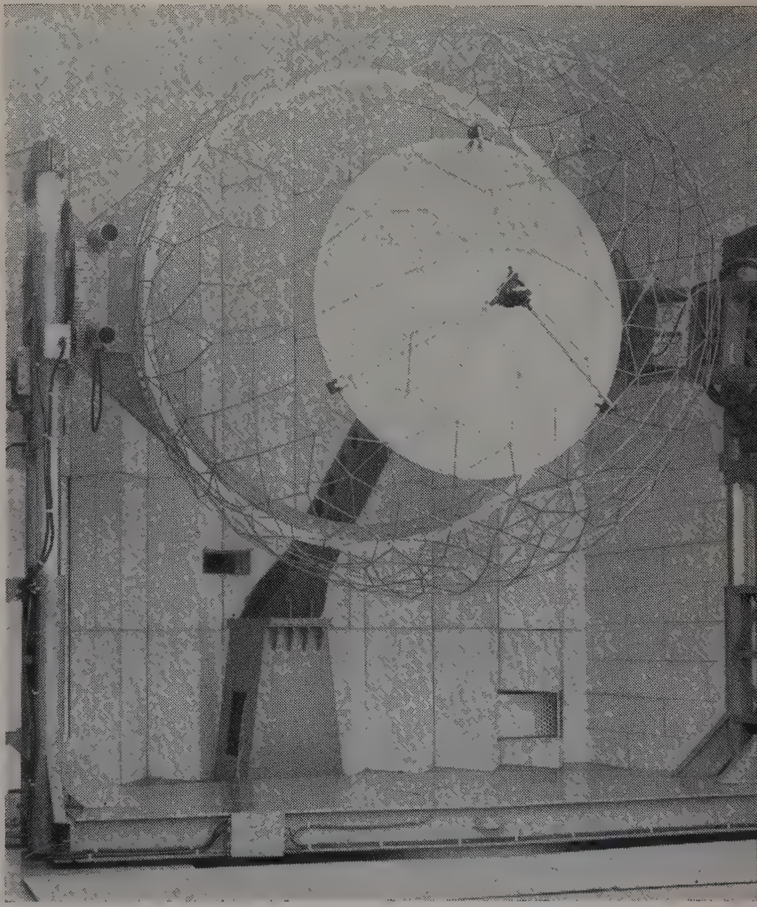


Figure 7 — Test antenna and test metal space-frame radome mounted to respective positioners for boresight evaluation.

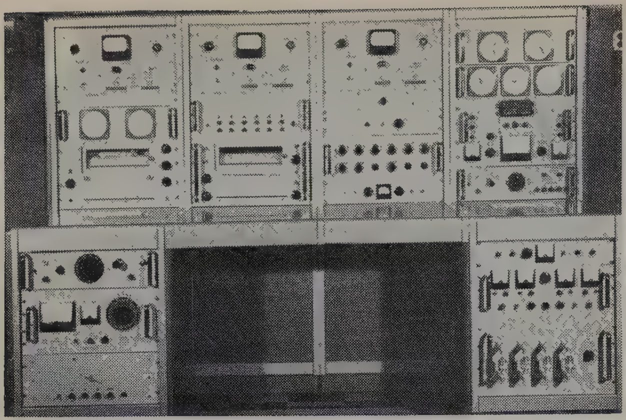


Figure 8 — Equipment console for operating long range station and measuring antenna-radome characteristics.

equipment for controlling the transmitting and receiving stations, and for recording test data. To provide additional flexibility for the facility any console can operate any long range transmitter station.

A typical console contains the following units:

(1) A wide range superheterodyne receiver.

(2) A rectangular pattern recorder.

(3) A control and indicator unit for the azimuth, elevation, and polarization test antenna positioners. The unit provides variable speed control of the positioners' motors and indicates the angular positions of these axes.

(4) Control and indicator unit for the transmitter tower and antenna positioner. This unit controls the four motions of the positioner and indicates the height and polarization of the transmitting antenna.

(5) Control unit for the transmitter station microwave source with frequency indication.

One of the consoles contains the necessary receiving and recording equipment so that in addition to antenna patterns, two-plane radome boresight shift, boresight shift error rate and radome transmission loss information can be obtained and automatically recorded. This console which is shown in Figure 8 is designed for use with two-plane monopulse antennas. The four channel receiver, the motor speed controller and positioner indicators for the radome and antenna mounts are seen at the extreme right. The three ratiometers which compare the appropriate signals from the antenna under test are on the upper portion of the console. Centrally located is the six channel boresight recorder. On the extreme left is the antenna pattern recorder, the remote motor speed controller and position indicators for the long range transmitter tower and antenna positioner and the remote frequency tuning unit for the long range RF energy sources.

The Transmitter Stations

At a distance of 2,000 feet from the receiver building and facing the test cubicles is the transmitter building which houses three transmitter stations. The front wall of this building is constructed of low density polyurethane foam. This material has an extremely low dielectric constant and loss tangent, so that waves are propagated to the

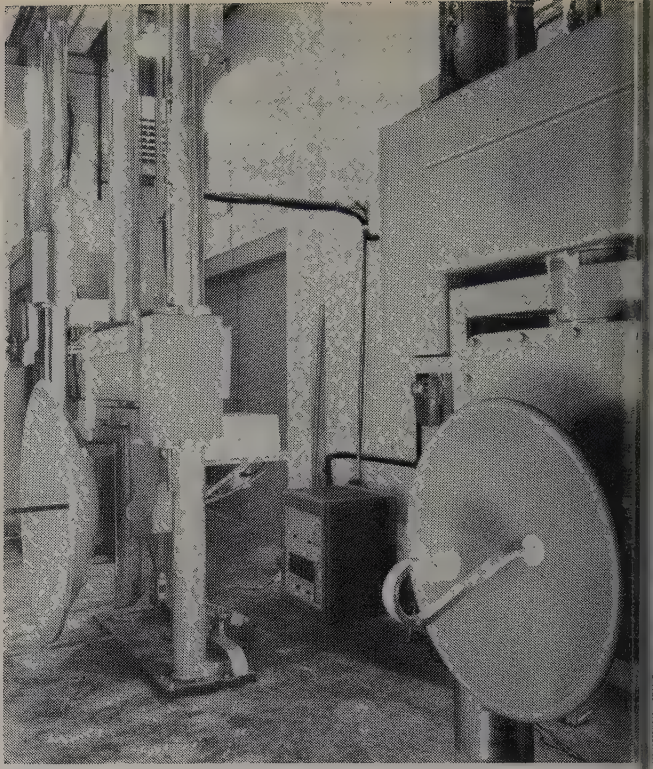


Figure 9 — Interior view of the long range transmitter building

receiver station through a wall essentially transparent to the RF energy, while maintaining all the equipment in weather proof surroundings.

Figure 9 shows an interior view of the transmitter building. Each station contains its own antenna mounted on a remotely controlled adjustable positioner, and RF energy source. The energy sources are low-power (approximately 100 milliwatts) backward wave carcinotron oscillators. The frequency of the carcinotron oscillators is adjustable by varying the anode voltage, and this feature simplifies the remote control of the transmitted frequency. The three transmitter towers are adjustable in height and the three axis positioners permit azimuth and elevation adjustment and continuous or discrete polarization change of the transmitting antennas. The RF energy sources are located in the white colored housings attached to the rear of the towers. All of the transmitter functions can be controlled either from any console located in the equipment control room of the receiver building or locally. The transmitting antennas are paraboloidal reflectors with linear polarized primary feeds and are designed to operate within the band from 2 to 16 kMcps. To permit continuous polarization rotation, the antenna input is coupled to the carcinotron output through a rotary joint. Four carcinotron tubes provide continuous frequency coverage from 2 to 16 kMcps in the following ranges: 2-4 kMcps 4-7.6 kMcps, 7-11 kMcps and 8-16 kMcps.

The short range transmitting station which is located 720 feet from the antenna positioner on the roof of the receiver building is shown in Figure 10. It includes the height adjustable tower, the three axis antenna positioner to which is mounted the 8 foot diameter transmitting antenna, and a housing for the electronic equipment. Interchangeable dipole feeds are provided for the reflector so that operation from .25 to 2 kMcps is obtained. The power supply for the tower and positioner motors and

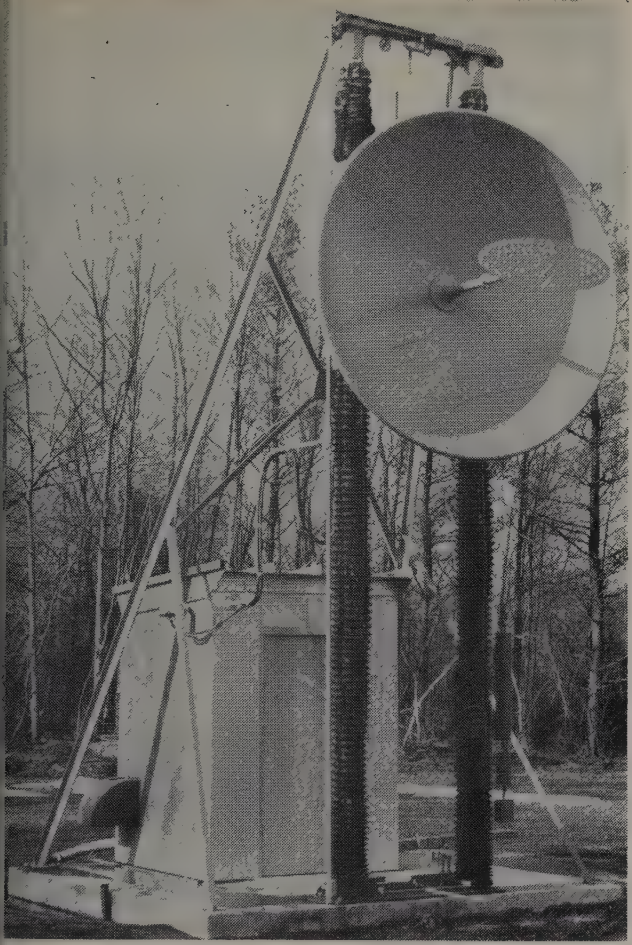


Figure 10 — The short range transmitter station.

synchros and the microwave oscillator units are contained in the equipment housing. Two oscillators provide continuous frequency coverage from .25 to 2.0 kMcps in the following ranges: .25 to .92 kMcps and .9 to 2.0 kMcps. As in the case of the long range, all of the transmitter functions can be controlled from the short range console in the receiver building or locally. Since this tower is exposed to the weather, flexible bellows protect the height adjust support guides as can be observed in the figure.

Results of Test Range Performance

The performance of the test range has been determined primarily by measuring the height-gain characteristics of the fields incident on the test cubicles. In addition, low side lobe antenna patterns were recorded inside the test cubicles to determine the effects of the cubicle on the antenna pattern. Further, measurements before, during and after severe precipitation storms (rain and snow) were also made to ascertain the all-weather capability of the facility.

The equipment used for measuring the height-gain characteristics of the test cubicles is shown in Figure 11. It consists of an 18 foot-high triangular tower, guy-supported to a wooden base. The carriage on the tower, which is used for mounting the test antenna probe, is motor driven and its height can be continuously varied.

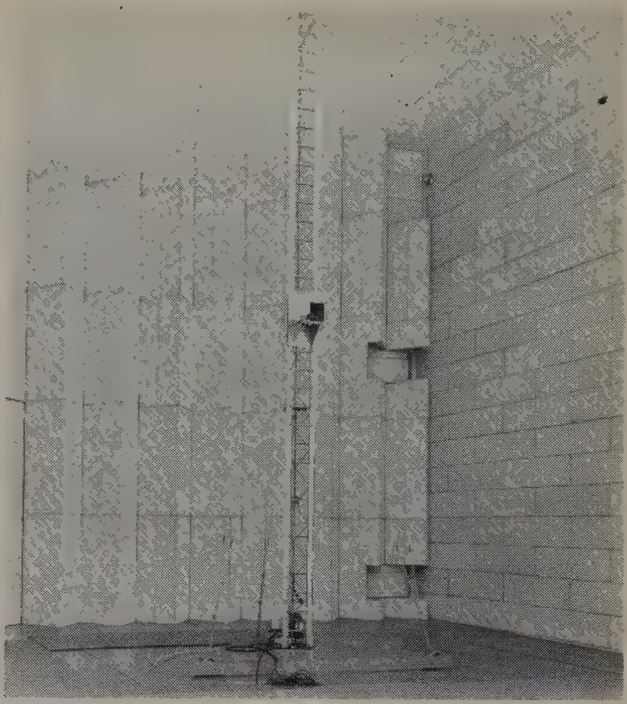


Figure 11 — Equipment used for measuring the height-gain characteristics at the test cubicle.

The height-gain characteristics at several positions in the test cubicle were obtained over a wide frequency band. Figure 12 shows typical height-gain characteristics measured at the center of the cubicle at 16 kMcps compared with the theoretical curve which assumes 100% reflection from the transmission path. The measured and theoretical curves are in excellent agreement, indicating that the transmission path is level and that an essentially plane wave results in this area. Figure 13 shows the height-gain characteristics at 7.2 kMcps measured with a 10 inch snow covering on the transmission path. The excellent agreement between the measured and theoretical curves indicates the all-weather capability of this facility.

In addition to measurement of the amplitude characteristics of the incident field, principal plane patterns of a typical paraboloidal antenna were recorded. Figure 14 shows a typical pattern taken at 15, 100 Mcps before and after a severe snow storm. Superimposed on these patterns in Figure 14 is the "mirror-image" pattern obtained after rotating the antenna 180° about its focal axis. The excellent agreement indicates that neither the snow covering nor test cubicle effects the antenna pattern as measured.

Conclusion

The Lincoln Laboratory antenna test facility introduces a number of innovations which result in substantial economic, engineering and operating advantages. The usual procedure of antenna measurements has been reversed by placing transmitting, receiving and measuring equipment proximate to ground level. The new facility makes possible automatic recording of patterns on antennas as large as 30 feet in diameter at any selected frequency between 0.25 — 2.0 kMcps. In addition, patterns for microwave antennas as large as 10 feet in diameter can be directly recorded at any frequency from 2.0—16.0 kMcps. Extension of the high frequency capability to 70 kMcps is presently being planned. Except for the low frequency

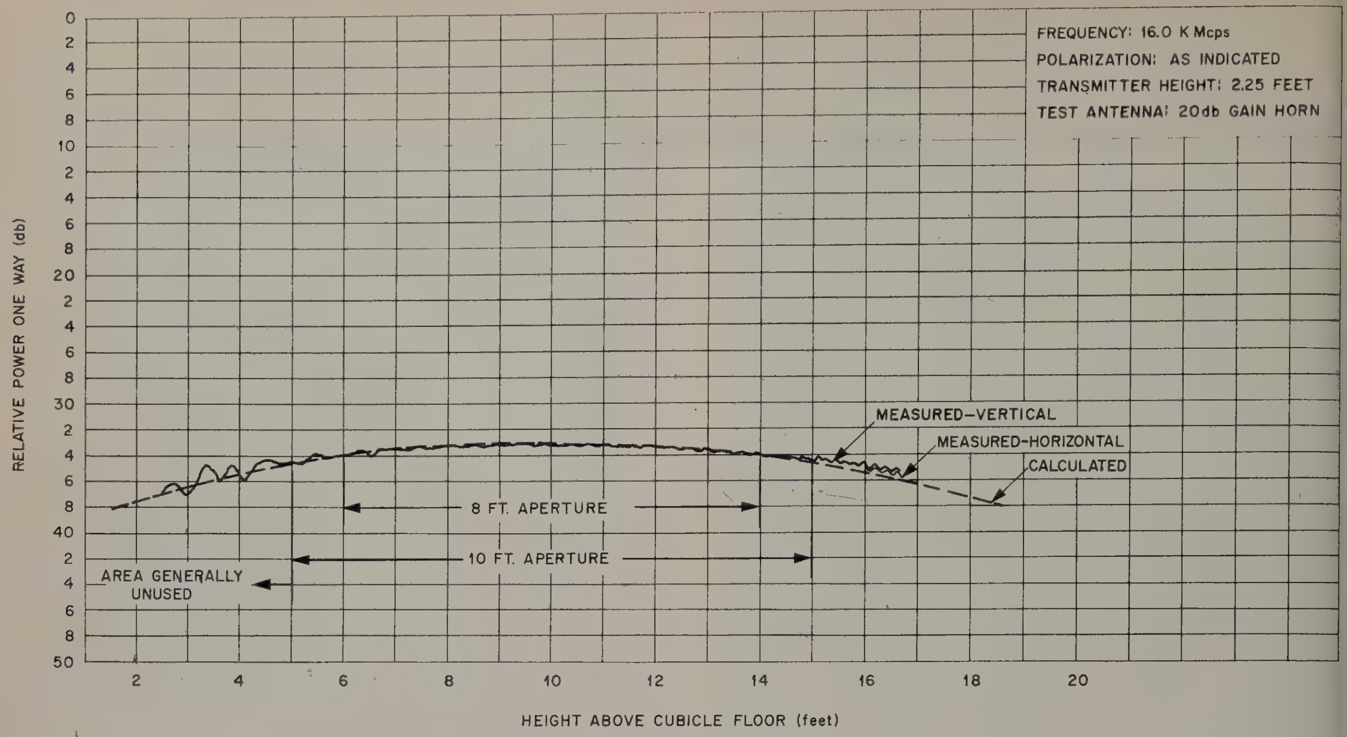


Figure 12 — Calculated and measured amplitude vs. height characteristic at center of antenna test cubicle, 16.0 kMcps Lincoln Laboratory antenna test range — 2000 feet long transmission path.

transmitting and receiving antennas, all equipment is housed inside permanent buildings so measurements may be made without interruption due to weather conditions. The use of low-power RF sources combined with the transmission of energy in narrow beams at the receiving stations, high gain frequency tuneable receivers, and microwave test cubicles, are all distinct advantages in eliminating interference to other radio services while at the same time preventing interference to antenna measurement performed on the site. In addition, the remote control fea-

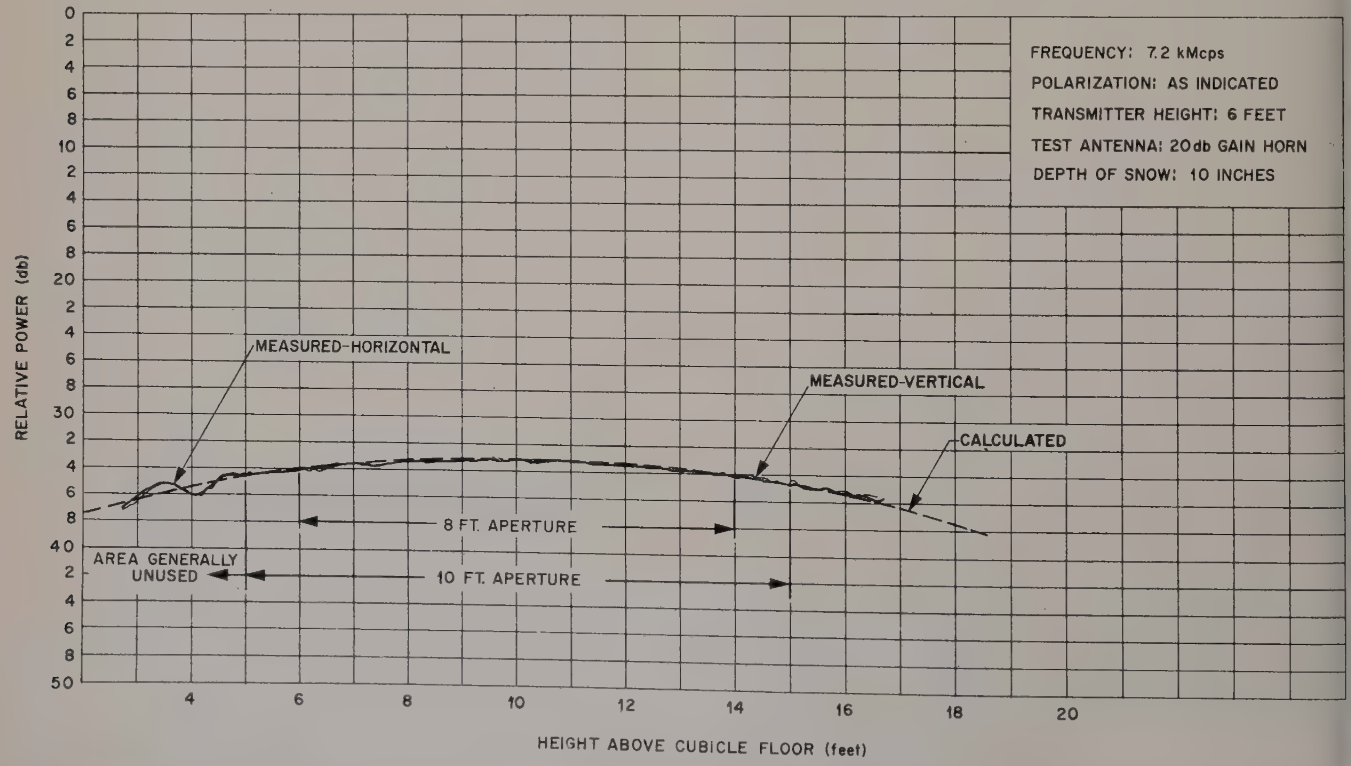
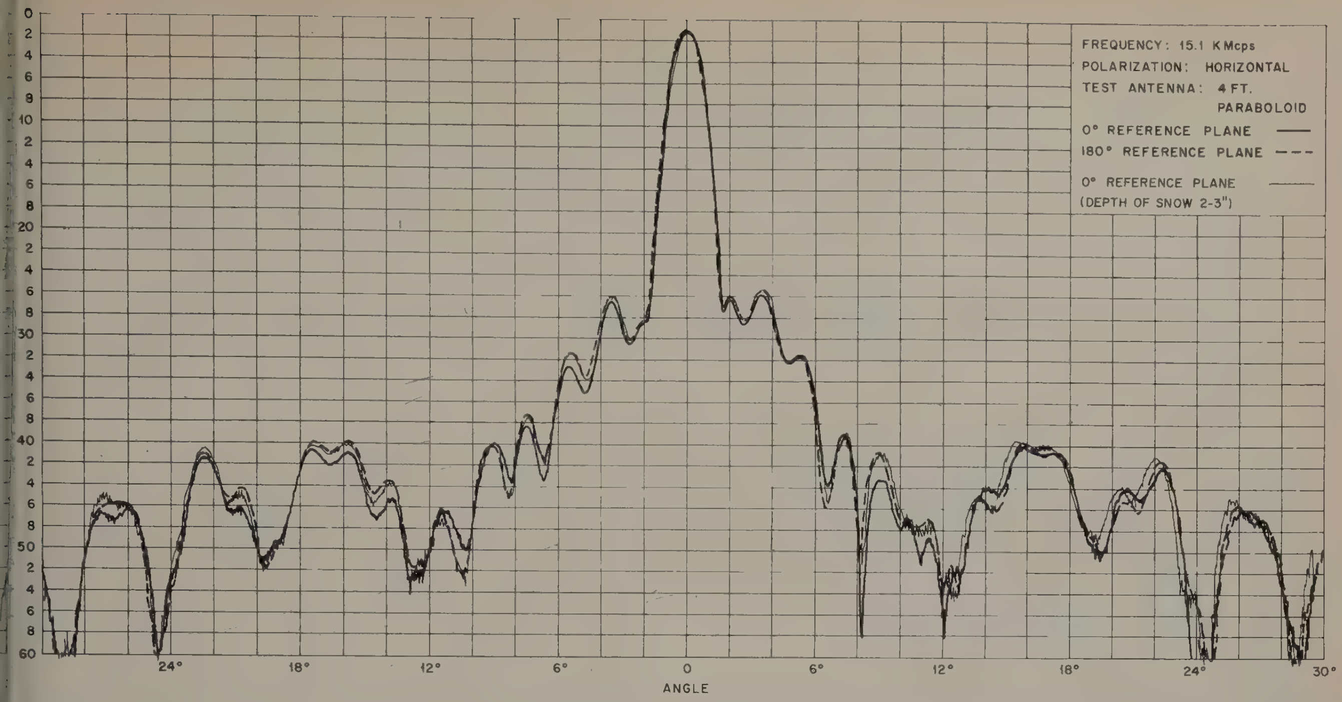


Figure 13 — Calculated and measured amplitude vs. height characteristic at center of antenna test cubicle, 7.2 kMcps, Lincoln Laboratory antenna test range — 2000 feet long transmission path covered with 10 inches of snow.



gure 14 — Typical E-Plane patterns, 0° (with and without snow) and 180° (mirror image), measured at the Lincoln Laboratory st range.

res and instrumentation, together with the ground level chnique, provide unusual flexibility of operation coupled ith consistent quality.

cknowledgments

The Lincoln Laboratory Antenna Test Range is the result of the coordinated efforts of many individuals, both internal and external to Lincoln Laboratory. In particular the authors would like to acknowledge the assistance of Mr. D. C. Moore, Assistant Leader of Group 75, who had the responsibility for the site construction and to Mr. J. A. Vitale, Engineering Division Head, for his advice and guidance throughout the project.

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THERMAL NOISE IN MICROWAVE SYSTEMS

Part II

Noise in High-Frequency Amplifiers, Particularly Masers

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A. PRACTICAL DESCRIPTION OF AN AMPLIFIER'S NOISE PERFORMANCE

In the past most common amplifiers were unilateral, i.e. they amplified only in the forward direction and had no significant gain for signals sent into the output end. Moreover, most amplifiers presented a positive-resistance impedance looking into either input or output terminals. Defining a meaningful noise figure does not present great difficulty under these circumstances. However, with the advent of negative-resistance amplifiers, such as the maser and the parametric amplifier, conventional noise figure definitions have become inadequate. Such amplifiers often present a negative-resistance impedance looking into input or output; and they sometimes amplify signals sent into the output equally as well as signals sent into the input.

It is difficult in such cases to give a general definition of noise figure which will have all of the following desirable properties: (a) be applicable to any linear amplifier; (b) give a good measure of the actual noise performance of the amplifier in practical situations; and (c) be a property only of the amplifier, independent of load or source impedances or their temperatures. Some excellent attempts at definitions have been made, particularly by Haus and Adler[5], but it can be argued that no definition can ever satisfy all three of the above requirements simultaneously. Fortunately, for many practical purposes the question of a general noise figure definition can be set aside, and one can be satisfied with a pragmatic approach which asks simply: what is the actual noise performance of an amplifier under its normal operating conditions?

Noise Performance

One way of describing the noise performance of an amplifier is the following. Consider a generalized two-port amplifier such as is shown in Figure 1. Such an amplifier in practice is normally intended to be operated looking out into matched resistive generator and load impedances. That is, the amplifier is normally constructed with input and output transmission lines, such as waveguides or coaxial lines, which are to be connected to matched terminations. In fact, the amplifier may not operate properly if it is not connected to matched generator and load impedances. This is not to say that a match is necessarily seen looking *into* the amplifier from either end. This is often not the case. Moreover, the heart of the amplifier may be a negative-resistance or other element which must be deliberately mismatched for proper operation. Normally, however, this necessary mismatch is incorporated internally as part of the amplifier, rather than being required as an external termination.

Consider, then, an amplifier which is intended to operate with matched generator and load, and which is actually being operated in this manner. We can describe the amplifier by its scattering matrix. Let a_i and b_i represent the ingoing and outgoing wave amplitudes, respectively, in the input ($i=1$) and output ($i=2$) lines. These wave amplitudes are normalized such that $|a_i|^2$ and $|b_i|^2$ represent the power flow in opposite directions. We can then define:

$g = b_2/a_1$ = forward 'voltage' gain
$G = |g|^2$ = forward power gain

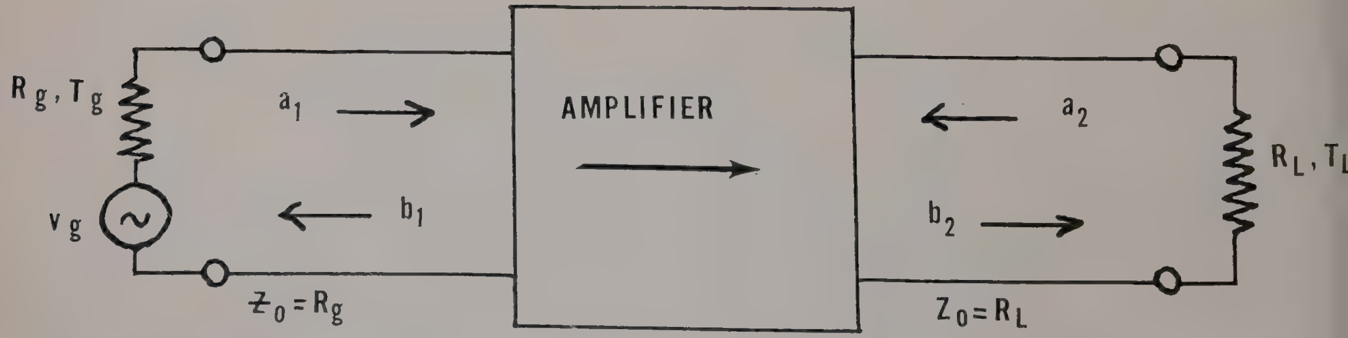


Figure 1 — A general representation of an amplifier.

$g_r = b_1/a_2$ = reverse 'voltage' gain

$\rho_1 = b_1/a_1$ = reflection coefficient looking into input with output terminated

$\rho_2 = b_2/a_2$ = reflection coefficient looking into output with input terminated

Using these quantities, the transfer characteristics of the amplifiers are given by the matrix equation

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} \rho_1 & g_r \\ g & \rho_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \qquad (1)$$

The matrix is the scattering matrix of the amplifier.

Such an amplifier will have three sources of noise output. (By 'output' is meant the amplitude of the outgoing wave b_2 in the output line of the amplifier). These are the amplified thermal noise from the source or generator resistance R_g at temperature T_g; internally generated noise power P_{na} due to noise sources inside the amplifier; and reflected noise from the load resistance R_L at temperature T_L. The total noise output of the amplifier will be

$$\text{Total noise output} = GkT_gB + P_{na} + |\rho_2|^2\ kT_LB \qquad (2)$$

Now, it is common practice to relate the noise output to an equivalent input noise temperature T_{eq}, and to relate the internal amplifier noise to an equivalent amplifier noise temperature T_a. The defining relations used are

$$\begin{aligned} &\text{Total noise output} = GkT_{eq}B \\ &\text{Amplifier noise} = P_{na} = GkT_aB \end{aligned} \qquad (3)$$

In terms of these temperatures, Equation (2) becomes

$$T_{eq} = T_g + T_a + |\rho_2|^2\ T_L/G \qquad (4)$$

We can now interpret the three terms.

The generator term T_g is due to the thermal noise in the source or generator connected to the amplifier. This term is, of course, inescapable. The temperature T_g is to be interpreted as the effective noise temperature of the source, which may be hotter than its physical temperature if there are other noise-generating mechanisms present. If the amplifier were the first stage of the receiver in the antenna example discussed in Part I, then T_g would be the T_{eff} calculated there.

The internal amplifier noise temperature T_a is the term which is most closely related to the noise figure of the amplifier, since it represents the noise generated internally in the amplifier. It is the term which one seeks to minimize by proper choice and design of a low-noise amplifier.

Finally, the output load noise term $|\rho_2|^2\ T_L/G$ is a term which was not significant in most amplifiers of the past, but which can be very important in modern ultra-low-noise negative-resistance amplifiers. The noise temperature of the load impedance is nominally room temperature, $T_L = 290°K$, if the load is a passive element. If the load is an active element, its apparent noise temperature may be even hotter — a diode mixer, for example, may send several thousand °K of noise back out its input line. In conventional amplifiers, the reflection coefficient $|\rho_2|^2$ looking into the output is at most unity, which means that T_L is reduced by at least a factor of 1/G. Negative-resistance amplifiers, however, may have a $|\rho_2|^2$ of the same order as G. They may amplify signals sent in the output equally as well as those sent in the input, and may send the amplified noise back out the output. This is obviously disastrous. Even if $|\rho_2|^2$ is only of order unity, a reasonably large value of gain G is necessary if the load noise term is to be reduced to a negligible value in a modern ultra-low-noise amplifier, in which T_a may be $\sim 10°K$.

Table I Noise Figure and Noise Temperature

Noise Figure F (in db)	Amplifier Noise Temperature T_a
20 db	29,000°K
10 db	2,600°K
6 db	870°K
3 db	290°K
1 db	75°K
0.5 db	35°K
0.1 db	7°K

In one-port reflection-type amplifiers, such as the cavity maser, a circulator is used in front of the cavity, and the load noise is no longer a problem, provided that the circulator is of high quality. Load noise can still enter via an imperfect circulator, however, as will be discussed in more detail in a later article.

Noise Figure

The conventional definition of noise figure F is

$$F = \frac{\text{Signal input/Noise input}}{\text{Signal output/Total noise output}} \qquad (5)$$

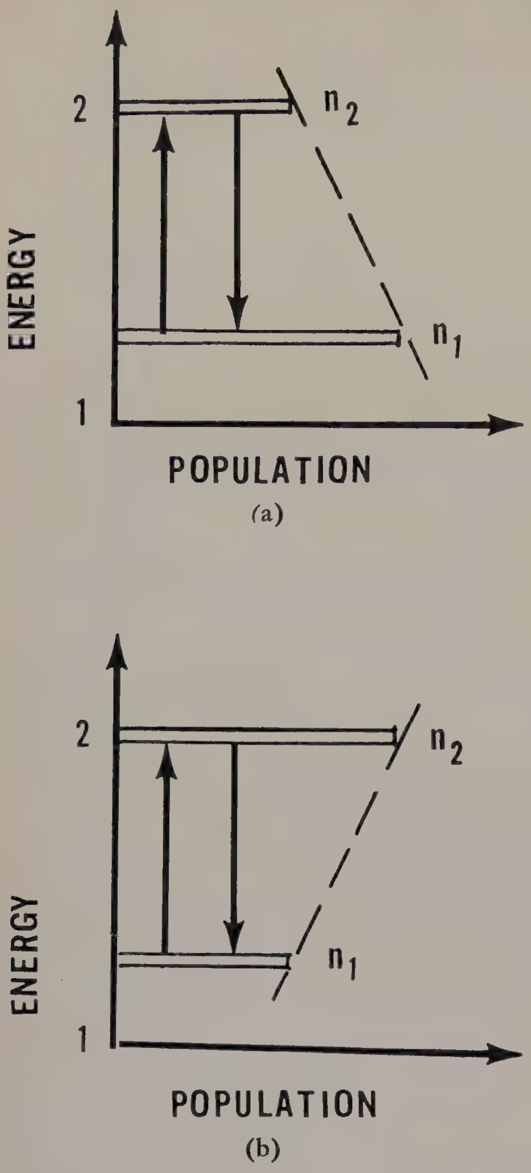
If signal input is interpreted as the power in the incoming signal wave in the input line and signal output as the power in the outgoing wave in the output line, then these are related by the power gain G. Moreover, the noise input under the same interpretation is just kT_gB. In terms of the noise temperatures just developed, the noise figure becomes

$$F = 1 + \frac{T_a + |\rho_2|^2\ T_L/G}{T_g} \qquad (6)$$

The usual noise-figure convention specifies that T_g is to be set equal to room temperature. Moreover, the load noise term was not usually important in the past, and hence was not included. With these restrictions, the noise figure reduces to

$$F = 1 + \frac{T_a}{290°K} \qquad (7)$$

The equivalent internal temperature T_a of a modern ultra-low-noise amplifier may be only a few degrees or tens of degrees Kelvin. The conventionally defined noise figure F is essentially unity in this case. Such an amplifier is likely to be used in physical situations where the source or background temperature T_g is very low, much less than room temperature. Under this condition the conventional noise figure F is not a very direct measure of the actual noise capability of the amplifier. Instead, it is becoming common practice to describe the noise performance of such an amplifier simply by giving the equivalent internal temperature T_a (often called the *amplifier noise tempera-*



(a)

(b)

Figure 2 — Two energy levels in a maser crystal spin system;
(a) positive-temperature or absorbing condition;
(b) negative-temperature or amplifying condition.

ture), together with some comment as to the effect of load noise if the amplifier is sensitive to T_L.

For comparison, Table I shows the relationship between noise figure F and noise temperature T_a, ignoring the load noise term. A convenient rule of thumb for noise figures less than one db is that each 1/10 of a db noise figure is equivalent to 7°K of noise temperature.

Sensitivity

The internal noise temperature T_a of an amplifier is a convenient direct measure of the amplifier's sensitivity as a receiver against various background temperatures. If the load noise term can be ignored, then the total power emerging from the amplifier when a signal is applied is

$$\text{Power out} = G[P_{in} + k(T_g + T_a)B] \qquad (8)$$

Therefore, an input signal of power level $P_{in} = k(T_g + T_a)B$ will double the power output from the receiver. The lower T_a is, the lower this signal power can be. However, it is clearly not very helpful to reduce the amplifier noise further once T_a is down to, say, one-tenth of the background temperature T_g. In fact, the improvement in signal input power needed to double output power is only 3 db when T_a is reduced from $T_a = T_g$ to $T_a = 0$.

Radio astronomers and others are sometimes interested not in signals against a background, but rather in detecting and measuring the background temperature T_g itself. The amplifier noise temperature has direct significance here also, since a source or background with temperature $T_g = T_a$ will just double the noise power output of the amplifier as compared to the output with a background temperature of $T_g = 0$.

B. NOISE GENERATION IN MASER SPIN SYSTEMS

The magnetic-resonance spin system in a solid-state maser crystal or other paramagnetic crystal generates thermal noise. This noise furnishes a fascinating example of the operation of fundamental physical laws in the strange world of negative resistances at negative temperatures. This noise also determines the ultimate limit on the noise figure of a maser amplifier or, as Part III will discuss, on the noise figure of any linear amplifier. A rigorous quantum treatment of noise in a maser crystal is, of course, far beyond the scope of this article. Fortunately, the results of such a detailed analysis for most instances can also be derived in simple fashion from some rather simple extensions of our results so far. In fact, noise in maser spin systems can be summarized in the following statement: *within the frequency bandwidth of the magnetic resonance transition, a maser spin system acts like a noisy resistance with a noise temperature equal to the spin temperature of the transition.* This statement holds for both positive resistance and temperature, and also for the more interesting and significant case of negative resistance and temperature.

Maser Fundamentals

Before going into the topic of maser noise, we must review some of the fundamental concepts of maser amplification and define some important terms. Masers amplify by causing atoms to jump back and forth between two energy levels 1 and 2, as shown in Figure 2. In the paramagnetic solid-state maser, these energy levels come from different orientations of the atom's spin in an applied magnetic field, and so the atoms are often called simply *spins,* the entire collection of atoms forming the *spin system.*

When an r-f signal at the proper transition frequency corresponding to the energy gap between levels is applied to the spin system, jumps or transitions occur in both directions. Each upward jump absorbs and each downward jump gives up one quantum of energy to the applied signal. In order to have more downward than upward jumps, and hence net amplification rather than net absorption, there must be more spins in the upper energy level 2 than in the lower energy level 1. This condition, called *population inversion,* is the basic requirement for maser action. Population inversion can be obtained in a variety of ways. For example, in the three-level maser population inversion is obtained by applying a strong pumping signal between one of the energy levels 1 or 2 and a third energy level not shown in Figure 2. In any

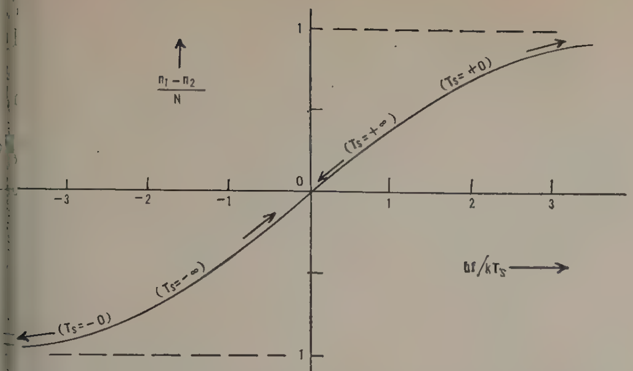


Figure 3 — The population difference n_1 - n_2 as a function of the Boltzmann factor exponent hf/kT_s, emphasizing the dependence on spin temperature T_s.

case, however, the maser's amplification and noise properties depend only on what the population inversion is, not how it is obtained. Hence, we can and will ignore the question of how the maser is pumped or otherwise activated.

Level Populations and Spin Temperature

Let the number of spins in the two energy levels 1 and 2 at any instant be n_1 and n_2, respectively, with the total number being $N = n_1 + n_2$. When a signal is applied to the spin system, the net power absorbed by the spins is proportional to the *population difference,* $n_1 - n_2$. The maser crystal can be represented in an equivalent circuit by an equivalent *spin resistance,* R_s, which is also directly proportional to $n_1 - n_2$. Now, under conditions of thermal equilibrium at temperature T, the populations of the two energy levels must obey the Boltzmann relationship $n_2/n_1 = \exp(-hf/kt)$ or $n_2 < n_1$. This means that there are always fewer spins in the upper level at thermal equilibrium. Therefore, the net power absorption and the value of R_s are always positive.

The condition for maser action, on the other hand, is more spins in the upper level, $n_2 > n_1$. Under this condition, R_s becomes a negative quantity. The net power absorbed by the spin system is negative, i.e. the spin system augments or amplifies the applied signal.

The Boltzmann relationship can now be extended to arrive at the important and useful concept of the *spin temperature,* T_s. We *define* the instantaneous temperature of the spin system under any conditions by relating T_s to the instantaneous level populations by the Boltzmann formula, i.e.

$$\frac{n_2}{n_1} = e^{-hf/kT_s} \qquad (9)$$

This expression is to be regarded as defining T_s in terms of n_1 and n_2. The spin temperature, defined in this manner, is a meaningful temperature for the spin system. If the spin system is in equilibrium with the outside world at temperature T, then T_s will be the same as T. Under other conditions, as in a maser, T_s may take on other, and especially negative, values.

In fact, from Equation (9) the only way in which the maser condition $n_2 > n_1$ can occur is for the exponent in the Boltzmann factor to become positive, and this must mean that T_s becomes a negative quantity. Thus, the equivalent circuit element for an inverted maser spin system is a negative resistance $R_s = -R_m$ with a negative temperature $T_s = -T_m$, where R_m and T_m are positive numbers, the subscript m standing for maser. We will see shortly that this combination results in positive noise generation.

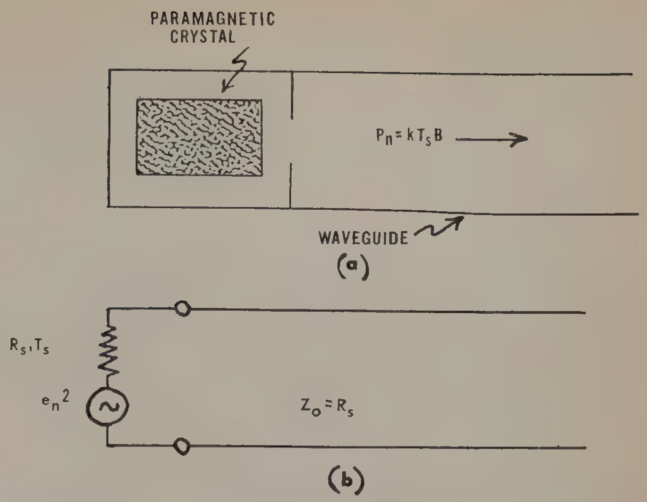


Figure 4 — (a) A waveguide terminated in a paramagnetic crystal (b) Equivalent circuit for analysis.

Equation (9) can be inverted to give the population difference $n_1 - n_2$ as a function of the quantity hf/kT_s. The formula is

$$\frac{n_1 - n_2}{N} = \tanh \frac{hf}{2kT_s} \qquad (10)$$

This expression is plotted in Figure 3, emphasizing the relationship between negative resistance and negative temperature. It is interesting to note that positive and negative temperatures join smoothly together by passing through $T_s = \pm\infty$, not $T_s = \pm 0$. Negative temperatures are in effect hotter than positive temperatures, rather than colder.

Spontaneous Emission

We turn now to the physical process which is really responsible for the noise in a spin system or maser crystal, namely the process of *spontaneous emission.* We have already noted that when a signal is applied to a spin system, the individual spins make transitions back and forth between the upper and lower levels. These transitions are *stimulated transitions;* that is, they are caused by the applied signal and are, therefore, coherently related to it. But, there also exist so-called *spontaneous transitions,* in which a spin in the upper energy level drops to the lower level, at the same time emitting a quantum of radiation at the transition frequency. These spontaneous transitions occur at random times, and are not coherent with any applied signal or with each other. Therefore, the radiation which they emit is essentially random noise within the linewidth of the transition involved. This process is called spontaneous emission.

The amount of spontaneous emission in a spin system at microwave frequencies is very small. Nonetheless, this is the mechanism basically responsible for noise generation in a maser spin system. The spontaneous emission noise will be amplified by the spin system in exactly the same fashion as is an applied signal, and will determine the ultimate noise figure of the maser.

One important attribute of spontaneous emission is that it is directly proportional to the number of spins n_2 in the upper energy level, since the spontaneous transitions originate there. The amount of spontaneous emission is independent of the number of spins in the lower energy level, n_1.

Spin System Noise Generation

We will now try to combine the above facts into a plausible if non-rigorous derivation of spin system noise. Consider a paramagnetic crystal whose spin system we will suppose, at least for the minute, is in a positive-T_s or absorptive condition. Let this crystal be placed in the end of a waveguide or other transmission line in such a fashion that the spin-system absorption perfectly terminates the waveguide over some narrow bandwidth B within the linewidth of the magnetic resonance line. It should always be possible to do this, using appropriate matching elements if necessary. Figure 4 shows such a terminated waveguide, together with a lumped equivalent circuit for the spin system termination, including a noise generator e_n^2.

Now, our earlier statements (in Part I) about the noise generation in an arbitrary termination must apply equally well to this case. The spin system must generate and send out into the waveguide noise power P_n given by

$$P_n = \frac{hfB}{e^{hf/kT_s} - 1} \approx kT_sB, \quad hf/kT_s << 1 \qquad (11)$$

This formula rests on purely thermodynamic foundations, and must be valid regardless of the actual physical mechanism responsible for the absorption in the termination.

The noise voltage generator e_n^2 necessary to create this outgoing noise power is given by

$$e_n^2 = 4\ R_s\ P_n = \frac{4R_shfB}{e^{hf/kT_s} - 1} \qquad (12)$$

$$\approx 4kT_sR_sB, \qquad hf/kT_s << 1$$

The spin temperature T_s is used here because it would seem to be the meaningful temperature to use for the spin system which creates the termination. Now, we have just stated that the noise in a spin system comes from spontaneous emission, and that the amount of spontaneous emission is proportional to n_2. Therefore, we hypothesize that e_n^2 should be proportional to n_2. But, this is, in fact, just the case. The numerator of Equation (12) contains R_s, which is proportional to $n_1 - n_2$, while the denominator is $e^{hf/kT_s} - 1$ which, by the definition of T_s, is equal to $n_1/n_2 - 1$. Combining these, we have

$$e_n^2 \sim \frac{n_1 - n_2}{n_1/n_2 - 1} = n_2 \qquad (13)$$

as we predicted.

We can now take the major step in the derivation. We note that because e_n^2 as given by Equation (12) is proportional only to n_2 and is independent of the population difference $n_1 - n_2$, the expression of Equation (12) will remain meaningful even when $n_1 - n_2$, R_s, and T_s all become negative quantities. We used the positive R_s and T_s case to arrive at Equation (12), but the equation remains valid — at any rate, it continues to give a noise voltage e_n^2 proportional only to n_2 — for negative R_s and T_s as well.

If we write $R_s = -R_m$ and $T_s = -T_m$ for the maser case, where R_m and T_m are the magnitudes of the negative quantities, then the noise voltage expression can be rewritten as

$$e_n^2 = \frac{4R_mhfB}{1 - e^{-hf/kT_m}}$$

$$\approx 4k(-T_m)(-R_m)B, \quad hf/kT_m << 1 \qquad (14)$$

We have arrived at the surprising result that the classical Johnson or Nyquist noise formula still holds even for a negative maser resistance: *the product of a negative resistance and a negative spin temperature gives a positive noise voltage.* The equivalent circuit for the amplifying maser crystal including noise generator is shown in Figure 5. This circuit is very convenient in making maser noise figure calculations, as we will see.

We can also generalize these results somewhat, as follows: we assert that any statements which can be made about thermal noise in an ordinary lossy element at temperature T can also be made about noise in a negative-resistance maser crystal, provided only that the negative spin temperature be used as the temperature of the negative resistance.

We have stated several times that a termination at temperature T delivers a noise power kTB per mode into a system. The reader may ask if this statement still holds when T becomes negative; and, if so, does a negative T mean that noise power flows *into* instead of out of the termination? The answer to this question is that this statement applies to a *matched* termination. If the temperature of a termination becomes negative, so does its resistance; and it is hard to see how one can terminate a real transmission line in a negative resistance (unless one has available a transmission line with a negative characteristic impedance!).

A statement about noise generation in a termination which is valid for T either positive or negative is that a termination delivers noise power to a transmission line according to the formula $(1-|\rho|^2)kTB$ where ρ is the reflection coefficient looking into the termination from the transmission line. The reader can verify this expres-

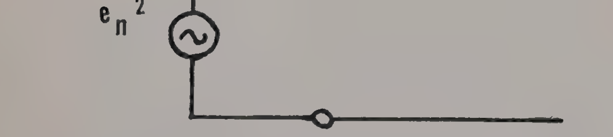


Figure 5 — The noise equivalent circuit for a maser crystal (assuming $hf/kT_m << 1$; cf. Equation (14) for exact formula).

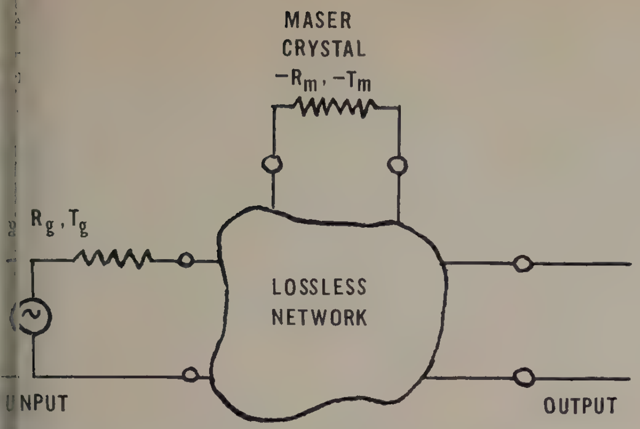


Figure 6 — Idealized representation of a maser amplifier.

ion for himself, using the expressions already given. If T goes negative, then the reflection $|\rho|^2$ becomes greater than unity, and the negative signs of the two factors T and $(1-|\rho|^2)$ cancel to give a positive noise output.

Other Types of Negative Resistance

The explanation of noise generation in negative resistances at negative temperatures developed here applies to maser negative resistances, but does not apply, at least not directly, to such other types of negative resistance as the negative resistances appearing in the tunnel diode or the parametric amplifier. These negative resistances have noise sources of their own, e.g. the tunnel diode has shot noise from the d-c bias current, and the parametric amplifier has thermal noise from the positive resistance in the idle circuit.

In a more general viewpoint, however, one can argue that a negative-resistance effect of any sort whatsoever must involve the lifting of particles into higher quantum energy states, from which they can drop in order to give amplification. Tunnel diodes and parametric amplifiers are not normally described in this fashion, but since the physical world is ultimately a quantized world if viewed on a small enough scale, such a description must be possible in principle. Now, spontaneous emission is an inescapable process whenever quantum systems are in higher energy levels. Therefore, it seems reasonable to conclude that there will be some component of noise associated with spontaneous emission in any type of negative resistance. The maser case is easily handled because the concept of spin temperature furnishes a simple and meaningful way to associate a negative temperature with the negative resistance. The difficulty in other negative resistances is the lack of any simple way to associate such a negative temperature with the effect.

C. THE THEORETICAL NOISE FIGURE OF A MASER AMPLIFIER

In this section we will compute the noise figures of the reflection-type cavity maser and the traveling-wave maser, using the conclusions about spin-system noise generation developed in the previous section. Ohmic losses inside the active maser device will be included, but external noise sources, such as imperfect circulators, will not. The latter will be discussed under the heading of 'practical difficulties' in Part III of these articles. For both the cavity maser and the traveling-wave maser, the minimum amplifier noise temperature T_a will turn out to be just T_m, the magnitude of the negative spin temperature. This result can, in fact, be obtained from a very general analysis, which will be the first topic discussed here.

General Noise Analysis

In the previous section we asserted that noise formulas and theorems derived for positive resistances can be applied to negative resistances as well, with a negative temperature being applied to the negative resistances. This statement can be applied to the noise theorem developed in Part I of these articles, and the noise theorem can then be used to find the noise figure of a maser amplifier in a very general manner.

Consider a generalized maser amplifier described as shown in Figure 6. The amplifier consists of a lossless three-port network, two of the ports being the maser input and output, the third port being connected to the negative resistance $-R_m$ which represents the maser crystal. For simplicity, no internal losses have been included, although they could be added on another port if desired. We will apply the noise theorem of Part I to this system, which represents an ideal lossless cavity or traveling-wave maser.

To apply the noise theorem, we need the transpose of this amplifier. If either a cavity or traveling-wave maser is transposed by reversing the d-c magnetic field, as suggested in Part I, the result is simply another maser amplifier amplifying in the opposite direction. Therefore, we hypothesize that this will be the case in general. Now, suppose that unit power is sent into the transposed amplifier through the (former) output port. The amplifier now amplifies this power in the reverse directions and a 'fraction' given by $\tilde{p}_g = G > 1$ reaches the source resistance R_g, where G is the power gain of the amplifier. The fraction reaching the negative resistance $-R_m$ is $\tilde{p}_m = (1-G) = -(G-1)$, so that $\tilde{p}_g + \tilde{p}_m = 1$, as required by the noise theorem. That the fraction $\tilde{p}_m$ should be a negative quantity is not unreasonable, inasmuch as it goes into a negative resistance.

The effective output temperature of the maser is given by multiplying the temperature of each resistance by its transposed weighting factor, i.e.

$$T_{eff} = \tilde{p}_g T_g + \tilde{p}_m(-T_m) = GT_g + (G-1)T_m \qquad (15)$$

The first term is clearly the amplified source noise, and the second term is equally clearly the internally generated noise from the maser crystal. To convert to amplifier noise temperature T_a, we must divide the latter term by the gain G, giving

$$T_a = \frac{G-1}{G} T_m \approx T_m, \quad G >> 1 \qquad (16)$$

This is the result claimed in the opening paragraph. The derivation given here may seem somewhat less than rigorous, but it will be verified in the direct computations for the cavity and traveling-wave masers.

It should be noted that this derivation contains the same assumption as does the noise theorem, namely an im-

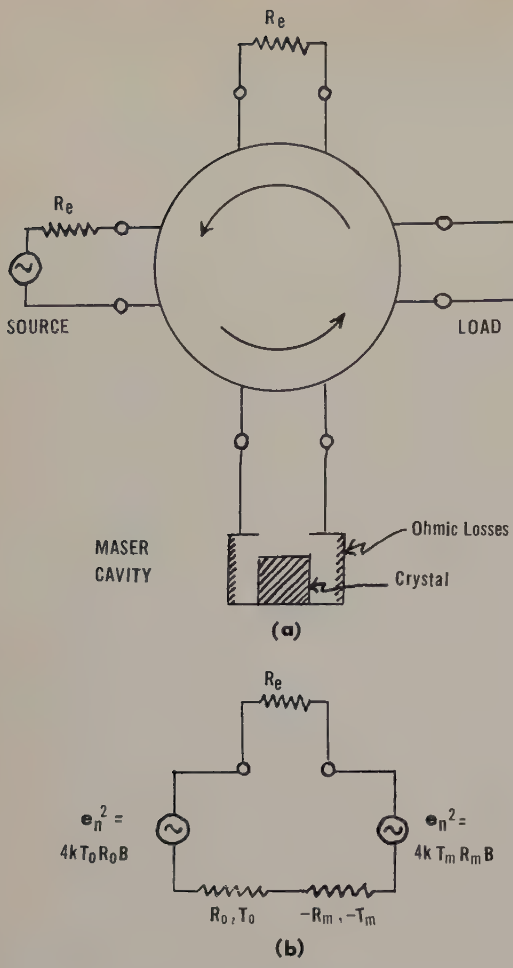


Figure 7 — (a) A cavity maser amplifier; and (b) its noise equivalent circuit.

pedance match looking into the output port of the system. This is the case in the circulator cavity and traveling-wave masers. It is not the case, for example, in two-port cavity masers, and so the noise discussion in such cases is more complicated, with load noise and the temperature of the load resistance being important considerations.

The One-Port Cavity Maser

Figure 7(a) shows a one-port or circulator type of cavity maser amplifier, including possible ohmic losses in the cavity, represented by an ohmic resistance R_o at the bath temperature T_o. All of the transmission lines and the matched source and load resistances are assumed to have the same value R_e (the subscript standing for *external*). We wish to compute the noise power P_{na} which is internally generated in the maser cavity and delivered to the load. Figure 7(b) shows the equivalent circuit appropriate for this computation, including the equivalent noise generators of the two resistances. For simplicity, the condition $hf/kT << 1$ has been assumed. Note in Figure 7(a) that noise from the load resistance is absorbed harmlessly in the fourth arm termination, and noise from the fourth arm is absorbed by the source. The noise from the source resistance is, of course, background noise, which is not to be assessed against the internal noise of the amplifier. Therefore, Figure 7(b) contains no noise generator associated with R_e.

The noise power P_{na} delivered to the output load resistance R_e is

$$P_{na}=4k\left[\frac{R_eR_mT_m+R_eR_oT_o}{(R_e+R_o-R_m)^2}\right]B \qquad (17)$$

The power gain G of such an amplifier is simply the square of the reflection coefficient seen looking into the cavity from the output line, i.e.

$$G=\left(\frac{R_e-R_o+R_m}{R_e+R_o-R_m}\right)^2 \qquad (18)$$

or

$$G-1=\frac{4R_e\ (R_m-R_o)}{(R_e+R_o-R_m)^2} \qquad (19)$$

Therefore, the internal noise temperature $T_a=P_{na}/GkB$ of the amplifier is given by

$$T_a=\frac{G-1}{G}\Bigg[\frac{R_m}{R_m-R_o}T_m+\Bigg[\frac{R_o}{R_m-R_o}\Bigg]T_o \qquad (20)$$

In a high-performance cavity maser of good design, the ohmic loss resistance R_o is much smaller than the magnitude of the negative resistance, R_m, or, in terms of Q's, the ohmic Q_o is much higher than the magnetic Q_m. With this restriction, Equation (20) reduces to

$$T_a=T_m+\frac{Q_m}{Q_o}T_o\approx T_m \text{ if } Q_o>>Q_m \qquad (21)$$

Thus, the internal noise temperature T_a of the maser is just equal to the magnitude of the negative spin temperature, T_m, if the cavity has no ohmic losses. If the cavity has small ohmic losses, then the second term above accounts for the thermal noise which they generate.

We may note here that if a quantity called in maser theory the *inversion ratio I* is greater than unity, then the negative temperature magnitude T_m can actually be smaller than the bath or ambient temperature T_o in which the maser operates. As a result, it is theoretically possible for the maser's noise temperature to be colder than its helium bath. A maser cavity noise temperature of <1°K is not unusual in practical masers. However, various practical difficulties external to the maser cavity make it impossible to achieve a complete maser amplifier with a noise temperature of this order. Some of these practical difficulties will be discussed in Part III.

The Traveling-Wave Maser

Derivation of the noise temperature of a traveling-wave maser is a straightforward task if two of our previous results are employed. In Part I of these articles, an expression was derived for the noise output of a lossy transmission line having two different loss mechanisms at different temperatures; while in the present article we have shown that maser material can be regarded as having noise properties appropriate to its negative loss at a negative temperature. We now combine these two results by considering the traveling-wave maser as a 'lossy' transmission line having two losses. Loss number one is a 'negative loss', i.e. a gain, due to the maser crystal with its negative temperature $-T_m$. This 'loss' can be described by a negative 'attenuation' coefficient $\alpha=-\alpha_m$. Loss number two is the total ohmic loss in the forward direction along the traveling-wave circuit, including ohmic losses in the slow-wave circuit or the maser crystal dielectric, and also any loss due to the finite from-to-back ratio of the reverse isolation employed in most traveling-wave masers. These losses can be summed up in an ohmic attenuation coefficient α_o with a corresponding temperature T_o, the bath temperature. The condition for net gain along the circuit is, of course, $\alpha_m > \alpha_o$, and the net forward power gain is $G = \exp[2(\alpha_m - \alpha_o)l]$.

Equation (24) of Part I gave for the noise output from a doubly lossy line the expression

$$\text{Noise output} = e^{-2(\alpha_1+\alpha_2)l} P_{in} + \left(1 - e^{-2(\alpha_1+\alpha_2)l}\right) k \left[\frac{\alpha_1 T_1 + \alpha_2 T_2}{\alpha_1 + \alpha_2}\right] B \qquad (22)$$

The first term represents input power transmitted down the line, while the second term is the noise power generated by the losses in the line. If we substitute for losses one and two the quantities appropriate to a traveling-wave maser, this term will be P_{na}, the internally generated maser noise:

$$P_{na} = (G-1)\, k \left[\frac{\alpha_m T_m + \alpha_o T_o}{\alpha_m - \alpha_o}\right] B \qquad (23)$$

Converted to amplifier noise temperature, this becomes

$$T_a = \frac{G-1}{G} \left[\frac{\alpha_m}{\alpha_m - \alpha_o} T_m + \frac{\alpha_o}{\alpha_m - \alpha_o} T_o\right] \qquad (24)$$

Finally, a good traveling-wave maser will have substantially more gain than loss, $\alpha_m >> \alpha_o$, and the power gain G will be much larger than unity. Also, the ohmic loss coefficient α_o and the gain coefficient α_m are proportional respectively to the ohmic loss L_o and the gain G if these quantities are expressed in db. Equation (24) can then be written

$$T_a \approx T_m + \frac{L_o(\text{db})}{G\,(\text{db})} T_o \approx T_m \text{ if } L_o << G \qquad (25)$$

Our prediction that $T_a = T_m$ in the lossless case is again verified.

It should be recalled at this point that all of these results are based on the assumption $hf/kT << 1$ made in the opening steps. The complications that arise when this is no longer valid will be discussed in greater detail in Part III.

Experimental Verification

Discussion of the experimental confirmation of our maser noise theory will be left until Part III in a later issue. However, we can say at this point that careful measurements on both cavity and traveling-wave masers are in excellent agreement with the theoretical measurements of this section. Problems in making accurate measurements of such small noise temperatures, especially because of the presence of other stronger noise sources in the same system, make such measurements difficult. However, there is little doubt that maser noise temperatures are in good agreement with theory. Maser amplifiers are, in fact as well as in theory, the lowest-noise amplifiers presently known.

References

The heuristic approach to spin-system noise generation presented in this article was first suggested to the author by Bloembergen. It has been used by most of the maser noise discussions listed below. More detailed and rigorous derivations of maser noise are to be found in the papers by Muller[6] and by Shimoda et al[8].

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Part III of Professor Siegman's paper will appear in the May issue of *the microwave journal.*

STANDARDIZATION *Of* RIDGED WAVEGUIDES

By TORE N. ANDERSON and LEONARD I. KENT

Standardization in the waveguide industry is an essential ingredient for the most economical growth and production of microwave components. Rectangular waveguides were standardized early — shortly after the war, using the existing dimensions for military waveguide tubing. These waveguides were not an overlapping series; also they were not ideal in that they were not exactly a two to one aspect ratio, for maximum bandwidth with minimum loss. Unfortunately, the pressure of the wartime effort with its extensive investment in tools and equipment precluded making any change. To provide an overlapping series of waveguides for system operating over bands between two of the original series, a "Series B" group of waveguide was standardized by the RMA (now EIA) in its standard TR-108. This standard has now been virtually adopted as the basis for an international standard. [1]

Rectangular waveguides have a bandwidth of something like forty percent. To meet the requirements for extremely wide band systems, a low loss transmission line capable of high power performance has been required. One solution to the problem of extending the bandwidth of waveguide transmission lines is to ridge load rectangular guide either by single or double ridge loading, as was proposed by Seymour Cohn[2] during the war.

Ridged waveguide techniques have found wide application in various broadband systems, principally for countermeasures application. History has repeated itself again in the waveguide industry in that several ridged waveguide sizes have found rather common usages which are not ideal from an electrical design point of view and create problems in meeting the total bandwidth requirement for each of these waveguide systems.

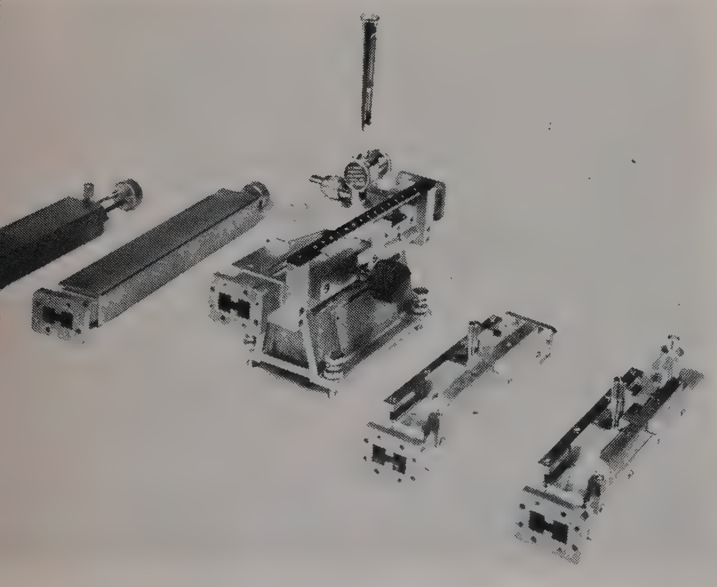
The EIA TR-21.1 Committee on Waveguides and Fittings (formerly the SQ-11.1 Committee), under the direction of Frank Klawsnik, RCA, Camden, N. J., with its sub-committees TR-21.1.1, headed by Tore N. Anderson, and TR-21.1.3 headed by Max Michaelson of Raytheon, has been trying to arrive at suitable standards for ridged waveguide which will avoid the pitfalls which have occurred in the rectangular waveguide standard.

Fortunately for the majority of rectangular waveguide applications, bandwidths are restricted to something either relatively narrow or from ten to twenty percent and thus the designer is not generally faced with the problem of working from the very low frequency limit to the very high frequency limit of each waveguide type.

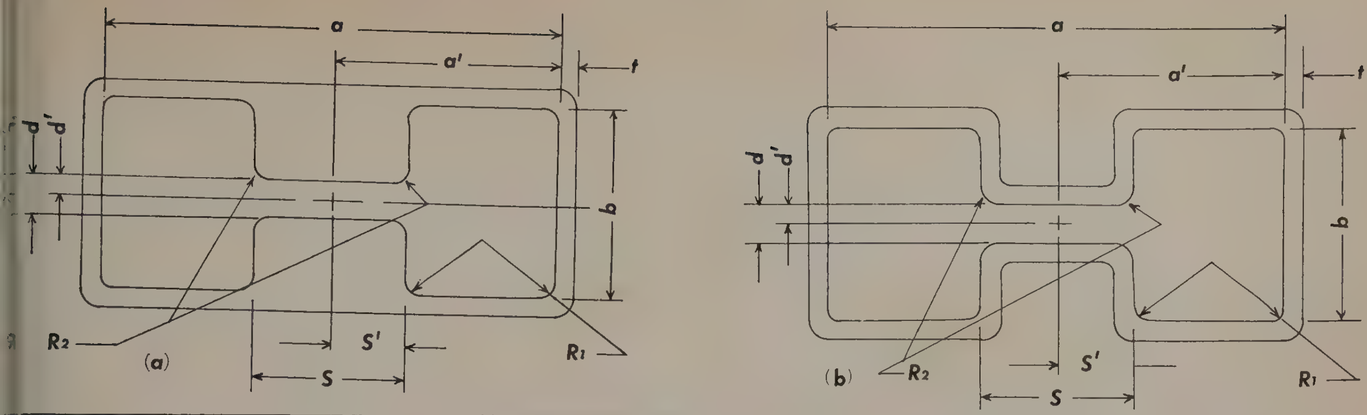
Ridged waveguide applications, on the other hand, almost invariably dictate full waveguide performance, and to adopt a standard which is not ideal seemed foolhardy. The first problem in trying to arrive at a standard for ridged waveguides was to decide the bandwidths required. The work of the committees for the first two years along these lines was to agree on frequency bands to be covered by the proposed ridged waveguide systems.

As a result of this effort, it was decided that basically two types of frequency ranges should be covered with this program.

(1) A frequency range of nominally somewhat over two to one, and for this a frequency range of 2.4 to 1 was



Double ridged waveguide slotted section tuners and terminations for the frequency band 4.75 to 11 Gc/s.
Photograph Courtesy Narda Microwave Corporation



Frequency Range (KMC)	fC10 (KMC)	λC10 (INS)	fC20 (KMC)	DIMENSIONS IN INCHES																f = √3 fC10		
				a	b	TOL.	d	[illegible]	TOL.	a'	TOL.	d'	TOL.	S'	TOL.	(t) Nominal	Deviation from mean [4]	R1 (MAX)	R2 [2]	ATT. db/FT.[1]	Power Hand Cap. (KW) [3]	FIG.
0.175-0.42	0.148	79.803	0.435	29.667	13.795	±.020	5.863	7.417	±.010	14.834	±.010	2.932	±.005	3.709	±.005				1.173	.00023	61,960	b
0.267-0.64	0.226	52.260	0.664	19.428	9.034	±.015	3.839	4.857	±.007	9.714	±.007	1.920	±.0035	2.429	±.0035				0.768	.00043	26,570	b
0.42-1.0	0.356	33.177	1.047	12.333	5.737	±.010	2.437	3.083	±.005	6.167	±.005	1.219	±.0025	1.5415	±.0025	0.125	±.005	0.050	0.487	.00085	10,710	b
0.64-1.53	0.542	21.792	1.593	8.100	3.767	±.010	1.601	2.025	±.004	4.050	±.005	0.8005	±.002	1.0125	±.002	0.125	±.005	0.050	0.320	.0016	4620	b
0.84-2.0	0.712	16.588	2.093	6.167	2.868	±.005	1.219	1.542	±.003	3.084	±.0025	0.6095	±.0015	0.7710	±.0015	0.125	±.005	0.050	0.244	.0024	2676	b
1.5-3.6	1.271	9.293	3.736	3.455	1.607	±.004	0.683	0.864	±.0025	1.728	±.002	0.3415	±.0013	0.4320	±.0013	0.080	±.005	0.050	0.137	.0058	840.5	b
2.0-4.8	1.695	6.968	4.984	2.590	1.205	±.004	0.512	0.648	±.002	1.295	±.002	0.2560	±.001	0.3240	±.001	0.080	±.005	0.050	0.102	0.0089	472.5	b
3.5-8.2	2.966	3.982	8.722	1.480	0.688	±.003	0.292	0.370	±.0015	.7400	±.0015	0.1460	±.0008	0.1850	±.0008	0.064	±.005	0.030	0.058	0.0204	154.3	b
4.75-11.0	4.025	2.934	11.842	1.090	0.506	±.003	0.215	0.272	±.001	.5450	±.0015	0.1075	±.0005	0.1360	±.0005	0.050	±.005	0.030	0.043	0.0324	83.72	b
7.5-18.0	6.356	1.858	18.680	0.691	0.321	±.0025	0.136	0.173	±.001	.3455	±.0013	0.0680	±.0005	0.0865	±.0005	0.050	±.005	0.020	0.027	0.0641	33.58	b
11.0-26.5	9.322	1.267	27.406	0.471	0.219	±.002	0.093	0.118	±.0005	.2355	±.001	0.0465	±.00025	0.0590	±.00025	0.040	±.005	0.015	0.019	0.114	15.63	a
18.0-40.0	15.254	0.7743	44.820	0.288	0.134	±.001	0.057	0.072	±.0005	.1440	±.0005	0.0285	±.00025	0.0360	±.00025	0.040	±.005	0.015	0.011	0.238	5.834	a

[1] Copper

[2] Radii Tolerance ± 10%

[3] Based on breakdown of air - 15,000 volts per CM (safety factor of approx. 2 at sea level) corner radii considered

[4] The mean wall thickness is one half the difference between the corresponding inside and outside dimensions at any cross section perpendicular to the axis

$\frac{f_{MIN}}{f_{C10}} = 1.18$ $\frac{f_{MAX.}}{f_{C20}} = 0.97$ $BWT = \frac{f_{C20}}{f_{C10}} = 2.94$

$S/a = 0.25$, $d/b = 0.425$, $b/a = 0.465$, $\frac{\lambda C10}{a} = 2.69$

$\frac{\lambda C20}{a} = 0.915$, $R_2 = 0.2d$, $an = 2.40$

Figure 1 — Proposed standard — double ridged waveguide 2.4:1 bandwidth

chosen as being most representative. The frequency bands for this series of guides are tabulated in Table I.

TABLE I
Frequency Range for 2.4 to 1 Ridged Waveguide, Gc/s

Series A	Series B
0.175 to 0.420	
	0.267 to 0.640
0.420 to 1.00	
	0.640 to 1.53
0.84 to 2.00	
	1.50 to 3.60
2.00 to 4.80	
	3.5 to 8.2
4.75 to 11.0	
	7.5 to 18.0
11.0 to 26.5	
	18.0 to 40.0

(2) For even wider bandwidth applications a frequency band of something close to three to one was chosen as the next desirable limit, and for this application an actual frequency range of 3.6 to 1 was chosen and the frequencies to be covered by this standard are tabulated in Table II.

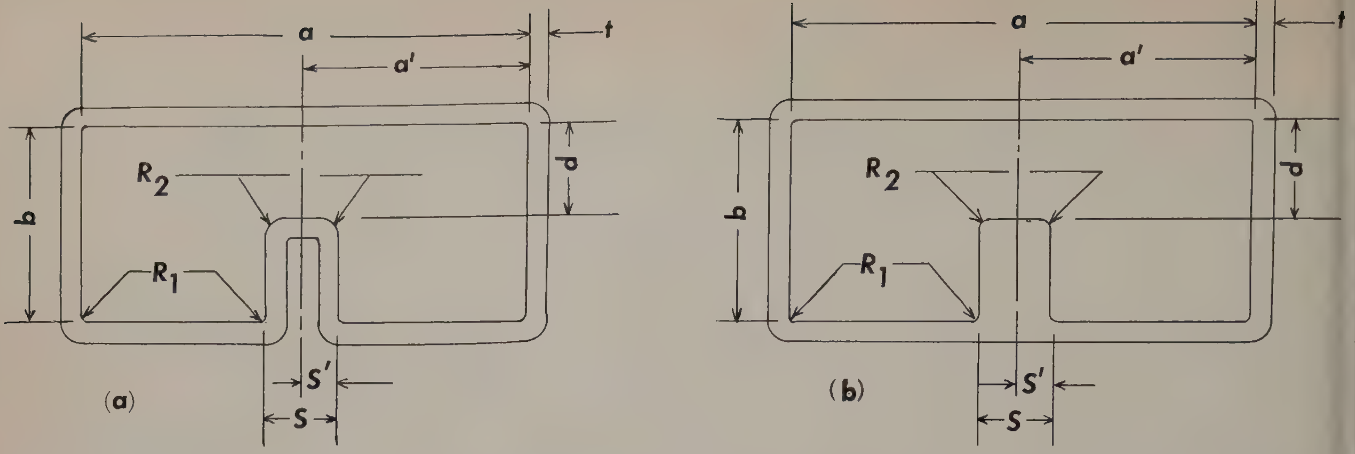
TABLE II
Frequency Range for 3.6 to 1 Ridged Waveguide, Gc/s

Series A	Series B
0.108 to 0.39	
	0.27 to 0.97
0.39 to 1.4	
	0.97 to 3.5
1.4 to 5.0	
	3.5 to 12.4
5.0 to 18.0	
	12.4 to 40.0

With the frequency ranges agreed upon for each of the series, the question of single ridged versus double ridged was discussed in committee in some detail. The single ridged waveguides find widest application where component designs are involved, such as slotted sections, directional couplers, hybrid crystal mixers, etc., in that the single ridge makes for quite a bit simpler mechanical construction of such devices. On the other hand, long transmission lines involving single ridge are somewhat difficult to fabricate in that a fairly heavy ridged loading in drawn tubing or in formed flexible waveguide is an extremely difficult mechanical problem to hold the required tolerance. Thus double ridged configurations have found wide acceptance in long transmission lines applications.

After considerable discussion it was decided that the best answer was to provide for standardization purposes both single and double ridged guides covering exactly the same frequency bands. Thus the waveguide impedances would be very nearly equal, and in this case, transition design from double to single ridge guide as required in various complex systems would be simplified. This would allow the system designer the choice of either single or double ridge guide to fit the application best.

At the start of this standardization effort, exact solutions for the performance of ridged waveguides, taking into account the effort of rounding the ridge corners for high power, the internal corner radius etc. had only been partially arrived at through the work of Sam Hopfer and Seymour Cohn. Exact expressions for the behavior



Frequency Range (KMC)	fC10 (KMC)	λC10 (INS.)	fC20 (KMC)	DIMENSIONS IN INCHES										(t) (NOM.)	Deviation from mean 4	R1 (MAX.)	R2 3	f = √3 fC10		FIG.
				a	b	TOL.	d	S	TOL.	a'	TOL.	S'	TOL.					ATT. db/FT 1	POWER Hand 2 CAP. (KW)	
0.175-0.42	0.148	79.803	0.431	28.129	12.658	±.020	5.278	4.360	±.010	14.065	±.010	2.180	±.005				1.056	0.00024	32,870	a
0.267-0.64	0.226	52.260	0.658	18.421	8.289	±.015	3.457	2.855	±.007	9.211	±.007	1.4275	±.0035				0.691	0.00045	14,100	a
0.42-1.0	0.356	33.177	1.036	11.695	5.263	±.010	2.195	1.813	±.005	5.848	±.005	.9065	±.0025	0.125	±.005	0.047	0.439	0.00087	5,682	a
0.64-1.53	0.542	21.792	1.577	7.682	3.457	±.010	1.442	1.191	±.004	3.841	±.005	.5955	±.0020	0.125	±.005	0.047	0.288	0.00164	2,451	a
0.84-2.0	0.712	16.588	2.072	5.847	2.631	±.005	1.097	0.906	±.003	2.9235	±.0025	.4530	±.0015	0.080	±.005	0.047	0.219	0.00248	1421	a
1.5-3.6	1.271	9.293	3.699	3.276	1.474	±.004	0.615	0.508	±.0025	1.638	±.002	.2540	±.0013	0.080	±.005	0.047	0.123	0.00591	445.8	a
2.0-4.8	1.695	6.968	4.933	2.456	1.105	±.004	0.461	0.381	±.002	1.228	±.002	.1905	±.0010	0.080	±.005	0.047	0.092	0.00908	250.6	a
3.5-8.2	2.966	3.982	8.632	1.404	0.632	±.003	0.264	0.218	±.0015	.7020	±.0015	.1090	±.0008	0.064	±.005	0.031	0.053	0.0212	81.87	a
4.75-11.0	4.025	2.934	11.714	1.034	0.465	±.003	0.194	0.160	±.001	.5170	±.0015	.0800	±.0005	0.050	±.005	0.031	0.039	0.0333	44.43	a
7.5-18.0	6.356	1.858	18.498	0.655	0.295	±.0025	0.123	0.1015	±.001	.3275	±.0013	.0508	±.0005	0.050	±.005	0.015	0.025	0.0661	17.82	b
11.0-26.5	9.322	1.267	27.130	0.4466	0.2010	±.002	0.0838	0.0692	±.0005	.2233	±.0010	.0346	±.00025	0.040	±.005	0.015	0.017	0.117	8.285	b
18.0-40.0	15.254	0.7743	44.393	0.2729	0.1228	±.001	0.0512	0.0423	±.0005	.1365	±.0005	.0212	±.00025	0.040	±.005	0.015	0.010	0.246	3.095	b

1 Copper
2 Based on Breakdown of air - 15,000 volts per CM (safety factor of approx. 2 at sea level) corner radii considered.
3 Radii Tolerance ± 10%
4 The mean wall thickness is one half the difference between the corresponding inside and outside dimensions at any cross section perpendicular to the axis.

$$\frac{f_{MIN}}{f_{C10}} = 1.18 \qquad \frac{f_{MAX}}{f_{C20}} \leq 0.98$$

$S/a = .155$, $d/b = .417$, $b/a = .45$

$$\frac{\lambda C10}{a} = 2.837, \quad \frac{\lambda C20}{a} = .9748, \quad R_2 = 0.2d$$

$$BWT = \frac{f_{C20}}{f_{C10}} = 2.91$$

$$BW\dot{O} = \frac{f_{MAX}}{f_{MIN}}$$

an = 2.25

Figure 2 — Proposed standard — single ridged waveguide 2.4:1 bandwidth

of ridged loaded waveguides is now available and these are described below.

The proportions of the ridged waveguides were chosen for optimum performance with regard to maximum power handling capacity, maximum gap spacing, and minimum attenuation for the specified bandwidths.

The ability to scale from one waveguide size to another was considered of prime importance in the establishment of the tables of the various waveguide sizes. Since the operating bandwidths are not exactly 2.4:1 or 3.6:1 for the different frequency ranges, caution was exercised in choosing the cutoff frequencies. Two criteria exist for the choice, which are very similar to each other. These are based upon identical values of theoretical bandwidth, BW_t:

$$BW_t = f_{c20}/f_{c10}$$

where:

f_{c20} = TE_{20} mode cutoff frequency

f_{c10} = TE_{10} mode cutoff frequency

or identical values for a nominal operating bandwidth, BW_o:

$$BW_o = f_2/f_1$$

where:

f_1 is the lowest operating frequency

f_2 is the highest operating frequency

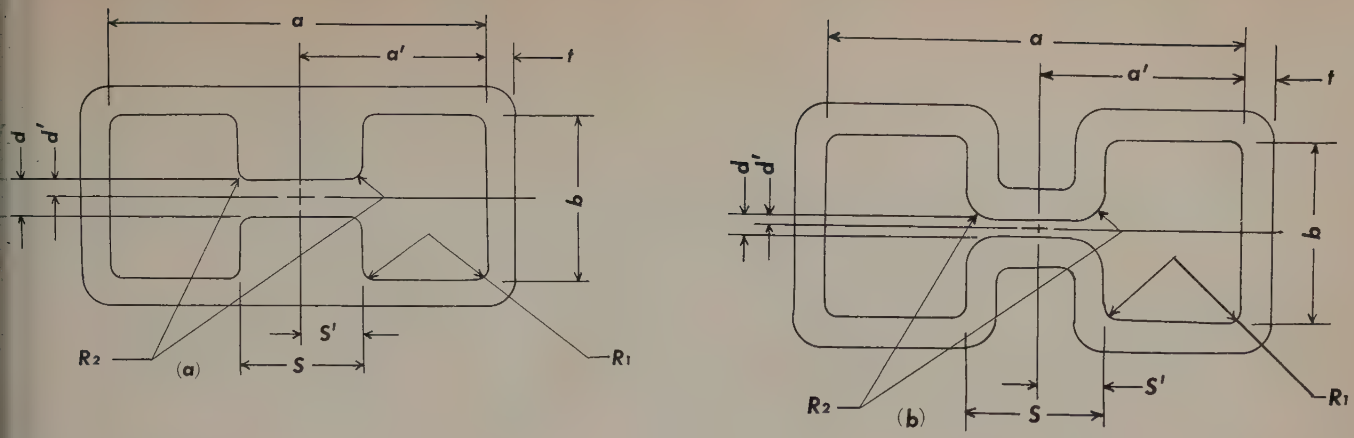
The difference in the two approaches is that one sets the TE_{20} cutoff at a particular level for all frequency ranges and permits the TE_{10} cutoff to fall where it may at some frequency less than the highest permitted. This approach leads to slightly less attenuation in the operating band. The other approach sets the TE_{10} cutoff at the same level for all frequency ranges and allows the second mode cutoff to fall at some higher frequency. This approach, although it leads to slightly more attenuation in the pass band permits all waveguides for the different frequency ranges to have the λg and Z_o variation with frequency. This completely permits scaling from one band to another.

During the early portion of 1958 the EIA sub-committee accepted the latter approach and set the dominant mode cutoff frequency and the second mode as follows:

$$f_1 = 1.18\ f_{c10}$$

$$f_2 \leqq .98\ f_{c20}$$

At this time the corner radii of the ridges were established



Frequency Range (KMC)	fC10 (KMC)	λC10 (INS)	fC20 (KMC)	DIMENSIONS IN INCHES																	$f = \sqrt{3}\, f_{C10}$		
				a	b	TOL.	d	TOL.	S	TOL.	a'	TOL.	d'	TOL.	S'	TOL.	(t) (NOM.)	Deviation from mean [4]	R_1 (MAX.)	R_2 [3]	ATT. db/FT [1]	Power Hand Cap (KW) [2]	FIG.
0.108-0.39	0.092	128.37	0.401	34.638	14.894	±.020	2.904	±.005	8.660	±.010	17.319	±.010	1.452	±.0025	4.330	± .005				0.581	0.0014	28,830	b
0.27-0.97	0.229	51.572	0.999	13.916	5.984	±.010	1.167	±.003	3.479	±.005	6.958	±.005	0.584	±.0015	1.740	±.0035				0.233	0.0055	4,653	b
0.39-1.4	0.331	35.680	1.444	9.628	4.140	±.010	0.807	±.0025	2.407	±.004	4.814	±.005	0.404	±.0013	1.204	±.0025	0.125	±.005	0.050	0.161	0.0097	2,227	b
0.97-3.5	0.822	14.367	3.587	3.877	1.667	±.004	0.325	±.0015	0.969	±.0025	1.939	±.002	0.163	±.0008	0.485	±.0013	0.080	±.005	0.050	0.065	0.0378	361.2	b
1.4-5.0	1.186	9.958	5.176	2.687	1.155	±.004	0.225	±.001	0.672	±.002	1.344	±.002	0.113	±.0005	0.336	±.001	0.080	±.005	0.050	0.045	0.0656	173.5	b
3.5-12.4	2.966	3.982	12.944	1.074	0.462	±.003	0.090	±.0005	0.269	±.0015	0.537	±.0015	0.045	±.00025	0.135	±.0008	0.050	±.005	0.030	0.018	0.259	27.74	b
5.0-18.0	4.237	2.787	18.490	0.752	0.323	±.0025	0.063	±.0005	0.188	±.001	0.376	±.0013	0.032	±.00025	0.094	±.0005	0.050	±.005	0.020	0.013	0.443	13.59	b
12.4-40.0	10.508	1.124	45.857	0.303	0.130	±.001	0.025	±.0005	0.076	±.0005	0.152	± 0005	0.013	±.00025	0.038	±.00025	0.040	±.005	0.015	0.005	1.730	2.210	a

1 Copper
2 Based on breakdown of air - 15,000 volts per CM (Safety Factor of approximately 2 at sea level) corner radii considered.
3 Radii Tolerance ±10%
4 The mean wall thickness is one half the difference between the corresponding inside and outside dimensions at any cross section perpendicular to the axis.

$$\frac{f_{MIN}}{f_{C10}} = 1.18 \qquad \frac{f_{MAX}}{f_{C20}} \leq 0.98$$

$$S/a = 0.25,\ d/b = 0.195,\ b/a = 0.430,\quad \frac{\lambda_{C10}}{a} = 3.706,\quad \frac{\lambda_{C20}}{a} = 0.8493$$

$$R_2 = 0.2d \qquad an = 6.50$$

$$BWT = \frac{f_{C20}}{f_{C10}} = 4.364$$

Figure 3 — Proposed standard — double ridged waveguide 3.6:1 bandwidth

at 20% of the gap d. This value is optimum from the point of view of power handling capacity, ease of fabrication, and electrical design consideration for components. The effects of the corner radii[8] have been completely accounted for in the calculations[7] for the design parameters of the proposed ridged waveguides.

Under the auspices of the U. S. Signal Corps[7] the Narda Microwave Corporation has participated in the program for obtaining the necessary technical background to make the design of the ridged standards feasible. In a future technical article, it is hoped that this new ridged waveguide design technique will be presented. To date, components have been made utilizing the proposed double ridged standard dimensions by Airtron in the 2-4.8 kMc range and the Narda Microwave Corporation in the 4.75-11.0 kMc range.

As a natural adjunct of ridged waveguide standardization, the EIA Sub-committee on Waveguides and Fittings proceeded to prepare an appropriate ridged waveguide flange standard. This standard takes two forms: The first is miniature flange standards for internal connections and the second is for pressurizeable junctions. Currently, proposed flange standards exist for the miniature types for double and single ridged guide in the 2.4:1 bandwidths and the pressurizeable types for the double ridged 2.4:1 bandwidth.

Conclusion

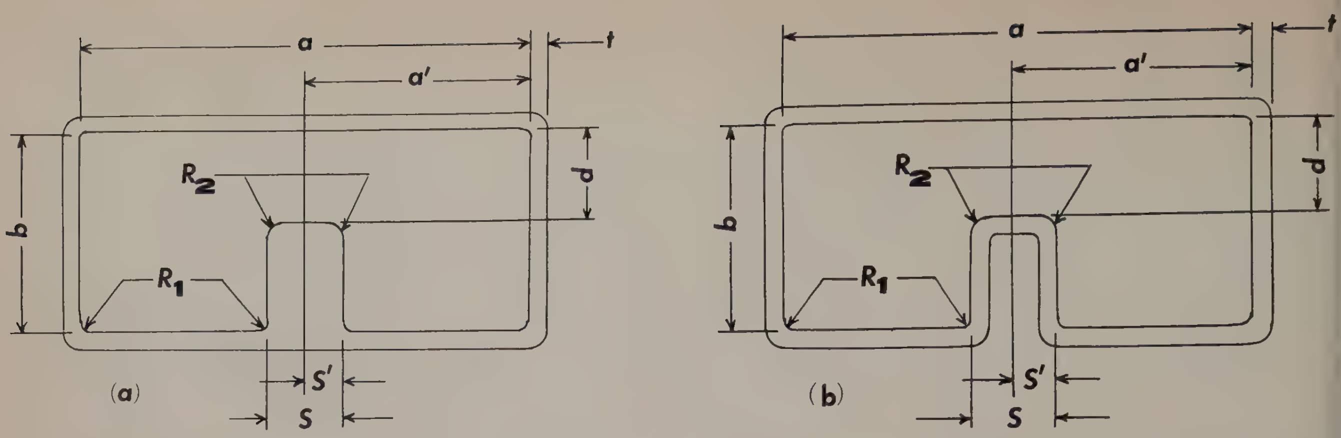
As a result of the efforts of the E.I.A. Sub-committee, the proposed ridged waveguide standard incorporates the following features:

a. Ability to scale designs from one waveguide size to another.
b. Optimum performance with respect to maximum power handling capacity and minimum attenuation for the given bandwidths.

Acknowledgments

The authors wish to acknowledge work done by the committee members of the EIA Sub-committee TR 21.1.1 and TR 21.1.3 on Flanges and New Type Waveguides respectively, in particular:

A Brenner	Narda Microwave Corporation
E. Hensperger	Narda Microwave Corporation
F. Klawsnik	Chairman of the Parent Sub-committee TR-21.1 - RCA
P. Levine	Narda Microwave Corporation
M. Michelson	Present Chairman TR-21.1.3 Raytheon
L. Moore	U. S. Signal Corps — Ft. Monmouth
R. Scudder	Former Chairman of TR-21.1.3 RCA



				DIMENSIONS IN INCHES															$f = \sqrt{3}\, f_{C10}$		
Frequency Range (KMC)	f_{C10} (KMC)	λ_{C10} (INS)	f_{C20} (KMC)	a	b	TOL.	d	TOL.	S	TOL.	a'	TOL.	S'	TOL.	t (Nominal)	Deviation from mean [4]	R_1 (MAX.)	R_2 [3]	ATT. db/FT [1]	Power Hand CAP (KW) [2]	FIG.
0.108-0.39	0.092	128.37	0.404	31.218	14.048	± .020	2.402	± .004	5.307	± .010	15.609	± .010	2.654	± .005				0.480	0.0016	14,550	b
0.27-0.97	0.229	51.572	1.006	12.542	5.644	± .010	0.965	± .003	2.132	± .007	6.271	± .005	1.066	± .0035				0.193	0.0065	2,348	b
0.39-1.4	0.331	35.680	1.454	8.677	3.905	± .010	0.668	± .0025	1.475	± .005	4.339	± .005	0.738	± .020	0.125	± .005	0.047	0.134	0.0112	1,124	b
0.97-3.5	0.822	14.367	3.611	3.494	1.572	± .004	0.269	± .0015	0.594	± .0025	1.747	± .002	0.297	± .0013	0.080	± .005	0.047	0.054	0.0438	182.2	b
1.4-5.0	1.186	9.958	5.210	2.422	1.090	± .004	0.186	± .001	0.412	± .002	1.211	± .002	0.206	± .0013	0.080	± .005	0.047	0.037	0.0758	87.56	b
3.5-12.4	2.966	3.982	13.030	0.968	0.436	± .003	0.075	± .0005	0.165	± .001	0.484	± .0015	0.083	± .0005	0.050	± .005	0.031	0.015	0.300	13.99	b
5.0-18.0	4.237	2.787	18.613	0.678	0.305	± .0025	0.052	± .0005	0.115	± .001	0.339	± .0013	0.058	± .0005	0.050	± .005	0.015	0.010	0.513	6.857	a
12.4-40.0	10.508	1.124	46.162	0.273	0.123	± .001	0.021	± .0005	0.046	± .0005	0.137	± .0005	0.023	± .00025	0.040	± .005	0.015	0.004	2.008	1.115	a

[1] Copper

[2] Based on break down of air - 15,000 volts per CM (safety factor of approx. 2 at sea level) corner radii considered.

[3] Radii Tolerance ± 10%

[4] The mean wall thickness is one half the difference between the corresponding inside and outside dimensions at any cross section perpendicular to the axis.

$$\frac{f_{MIN}}{f_{C10}} = 1.18 \qquad \frac{f_{MAX}}{f_{C20}} \leq 0.98$$

$$S/a = 0.170, \quad d/b = 0.171, \quad b/a = 0.450$$

$$\frac{\lambda_{C10}}{a} = 4.112 \qquad \frac{\lambda_{C20}}{a} = 0.936 \qquad R_2 = 0.20d$$

$$BWT = \frac{f_{C20}}{f_{C10}} = 4.393 \qquad BWO = \frac{f_{MAX}}{f_{Min}}$$

$$an \simeq 8.30$$

Figure 4 — Proposed standard — single ridged waveguide 3.6:1 bandwidth

References

The following references will be helpful in reviewing the aspects of ridged waveguides and their design. Reference 7 outlines and illustrates the calculations that were made for these proposed standards.

1. Microwave Journal editorial by Tore N. Anderson, "Report on International Conference for Waveguide Standardization" dated January, 1960.
2. Very High Frequency Techniques, Volume 1 and Volume 2, Radio Research Laboratories staff — Harvard University.
3. "Broadband Waveguide Transmission Systems and Components" Final Report — Contract No. NObsr-39294, July, 1947 — August 1949, Navy Department —Bureau of Ships.
4. "Extremely Broadband Waveguide Components," Final Report — Contract No. Da-36-039-SC-42662, April 1953 — June 1954, Signal Corps Engineering Laboratories.
5. "Broadband Ridged Waveguide Components," Final Report — Contract No. AF 30(602) — 1426, November 1955 — October 1956, Rome Air Development Center, ARDC.
6. "Design of Ridged Waveguides" — Sam Hopfer, IRE Transactions, Volume MTT-3, Number 5, October 1955.
7. "Broadband Ridge Waveguides and Components," First Quarterly Report — Contract No. DA-36-039-SC-78187, December 1958 — February 1959, U. S. Army Signal Engineering Labs.
8. Unpublished Notes of Seymour B. Cohn.

* * *

A SIMPLE APPROXIMATE EXPRESSION FOR CONVERTING DIRECTLY FROM NOISE FIGURES IN DB TO NOISE TEMPERATURES

E. P. McCURLEY and C. BLAKE
LINCOLN LABORATORY*
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington • Massachusetts

In the field of low noise receivers it is widespread practice to relate the noise contribution of a circuit and the noise figure of a device to so-called noise temperatures. As a result, a worker in this general area finds it frequently necessary to convert from noise figures to noise temperatures, and vice versa, by means of the rather well-known relationship for single response amplifiers,

$$T=(F-1)\ T_o,$$

where T is the noise temperature, F is the noise figure expressed as a numerical ratio and $T_o=290°$ Kelvin .

It occurred to the writers that a simple expression relating the noise temperature to the noise figure as usually given in db would be of value on those occasions when one finds himself wishing to make a noise figure to noise temperature conversion by means of mental arithmetic or only a pencil and a piece of paper. Since the noise temperature concept is most useful when applied to low noise devices having noise figures of 3 db or less, it appeared that a simple relationship which approximated the exact expression over the range of noise figures from 0 db to 3 db with an error of only a few per cent would be acceptable. Such a relationship may be readily obtained by writing

$$F_{db}=10\log_{10}F=4.343\log_e F$$

and approximating $\log_e F$ by the first term of the series expansion,**

$$\log_e x=2\left[\frac{x-1}{x+1}+\frac{1}{3}\left(\frac{x-1}{x+1}\right)^3+\frac{1}{5}\left(\frac{x-1}{x+1}\right)^5\right]+\ldots,\ (x>0). \tag{1}$$

We then have

$$F_{db}=8.686\,\frac{F-1}{F+1}, \tag{2}$$

$$F=\frac{8.686+F_{db}}{8.686-F_{db}}=1+\frac{2F_{db}}{8.686-F_{db}}, \tag{3}$$

$$T_{approx}=\frac{2F_{db}\,T_o}{8.686-F_{db}}=\frac{580\ F_{db}}{8.686-F_{db}}\ °K. \tag{4}$$

For simplicity we may take

$$T_{approx}=\frac{600\ F_{db}}{9-F_{db}}\ °K \tag{5}$$

with the corresponding inverse relationship given by

$$F_{db_{approx}}=\frac{9T}{600°K+T}\ db. \tag{6}$$

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* *Operated with support from the U.S. Army, Navy and Air Force.*

** *Burington, Handbook of Mathematical Tables and Formulas, Handbook Publishers, Inc., 3rd Edition, 1955, p. 44.*

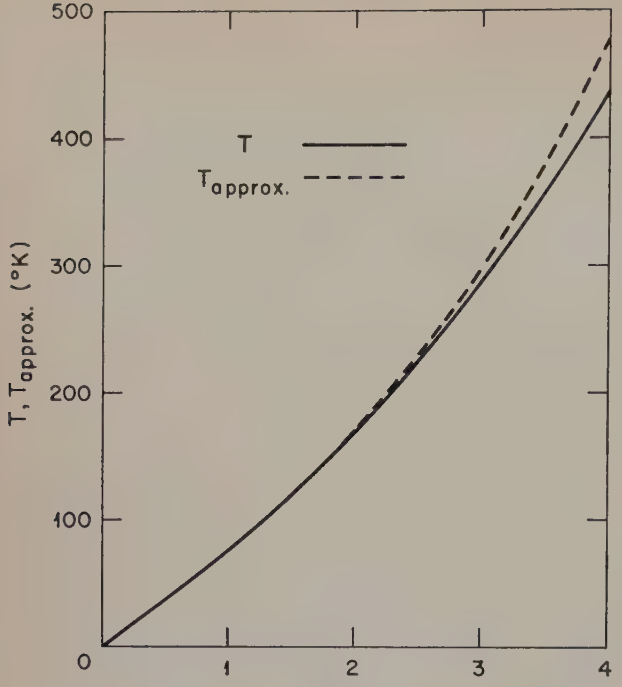

Figure 1 — T, $T_{approx.}$ vs. F_{db}.

TABLE I

F_{db}	T(°K)	T_{approx}(°K)	Error (%)
0	0	0	0
0.1	6.76	6.74	−0.3
0.5	35.4	35.3	−0.3
1.0	75.1	75.0	−0.1
1.5	119.6	120.0	+0.3
2.0	169.6	171.4	+1.1
2.5	225.7	230.8	+2.3
3.0	288.6	300.0	+4.0
3.5	359.2	381.8	+6.3
4.0	438.4	480.0	+9.5

Figure 1 shows plots of the approximate noise temperature calculated from equation (5) and the actual noise temperature vs. noise figure, while Table 1 gives a comparison of these temperatures for several values of noise figure in the range from 0 db to 4 db. It may be seen that the approximation is within 4.0 per cent for noise figures up to 3 db with the error increasing to 9.5 per cent at 4 db. Slightly smaller percentage errors result from the use of equation (6) to approximate F_{db}. Obviously, the final relationships could be refined somewhat to improve the accuracy of the approximation, but for those workers who customarily deal with noise figures of 3 db or less, such improvement would appear to be of little value.

MEASURING HIGH POWER BREAKDOWN

GERSHON WHEELER*
SYLVANIA ELECTRIC PRODUCTS, INC.
MICROWAVE DEVICE OPERATIONS
Mountain View • California

Because of the ever-increasing peak powers desired in radar systems, it becomes necessary to design waveguide components ahead of the state of the art in power handling capability. That is, these components must be able to carry peak powers greater than what is presently realizable from currently available tubes. Consequently, after the waveguide components are designed and developed, there remains two measurement problems: (1) the determination of the breakdown power, and (2) if the breakdown occurs at too low a power, the determination of the location of the weak point.

Of course, the simplest and most direct method of determining the breakdown power is to connect the component to a suitable high power source, increase the power slowly, and note at what level breakdown occurs. However, in designing for breakdown beyond the state of the art, it is assumed that there exists no source with peak power sufficient to cause breakdown in the new component. In order then to cause breakdown, either the peak power from the source must be increased when it arrives at the component under test, or the breakdown power of the component must be decreased a predetermined amount. Both methods are feasible.

A common method of increasing the peak power inside the component is to place a discontinuity beyond it, thus causing a standing wave in the line. The maximum peak power in the line is now $(1+|\Gamma|)^2$ times the incident peak power and, with a short circuit, may be four times as much. If the discontinuity or short can be moved along the line, the standing wave will move with it, and the point of maximum peak power will presumably be made to pass through the weakest part of the component under test. The movement may be accomplished by using a high-power phase shifter.

A better, but more complicated method of increasing the peak power is by using a resonant ring. Here, there is no variation along the line, and all parts of the component are subjected to the same peak power uniformly. This method was described in the September, 1960, *microwave journal* in an excellent paper by Stanley Miller.

The breakdown power of the component can be lowered by lowering the pressure inside the waveguide. It has been determined empirically that at pressures ranging from one-half to one atmosphere the breakdown power is proportional to the pressure. At pressures from one-half atmosphere down to about one-fifteenth atmosphere the breakdown is proportional to the square of the pressure. These results were observed in waveguide and vary with the type of gap. Consequently, this method is not recommended where high accuracy is required.

When breakdown occurs, even if well above specifications, it is usually desirable to know where in the component this happened. Sometimes this is obviously the narrowest gap in the guide, but in complicated components this is not necessarily so. At any rate, improvement in design is difficult until the cause of failure is found.

The point of breakdown can sometimes be found by visual inspection. On a brass piece especially, black spots mark the place where breakdown has occurred. This method is useful when arcing occurs between flanges since the spots are easily seen. A cystascope may be used to look inside the guide at otherwise inaccessible places, but detection there is more difficult.

Paper placed between the points of breakdown will show evidence of arcing. Scientific instrument suppliers sell a special wax paper, called "coated paper for spark recorders," which changes color from a pale pink to a dark red when breakdown occurs through it. This is the simplest method to detect breakdown which occurs between separated parts of a component.

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* *Editorial Specialist, the microwave journal.*

If the component is relatively simple, it may be filled completely with polyfoam with very little change in its electrical properties. When breakdown occurs, the polyfoam carbonizes, and the dark line shows the location of the difficulty.

When breakdown is the result of a poor or soldered joint, it probably will not leave a trace which can be detected by any of the aforementioned methods. It becomes necessary to see it while it is happening. This can be done by looking into the waveguide through a below-cut-off tube. The cut-off wavelength of the lowest or dominant mode of a round waveguide is 1.706 times the diameter. The attenuation through it in db is

$$54.5\frac{l}{\lambda_c}\sqrt{1-\left(\frac{\lambda_c}{\lambda}\right)^2} \quad \text{where } l \text{ is the length.}$$

The length and diameter are chosen to attenuate the signal sufficiently to prevent damage to the eye of the observer. The tube is usually soldered to an elbow which is placed in the circuit so that the observer can look right into the component being tested.

If the component is intricate, it is sometimes desirable to replace a whole wall with close-spaced metal screening. It is necessary that the screening be of the variety which has soldered intersections. Now it is possible to see what is happening inside the whole unit, with practically no danger from radiation.

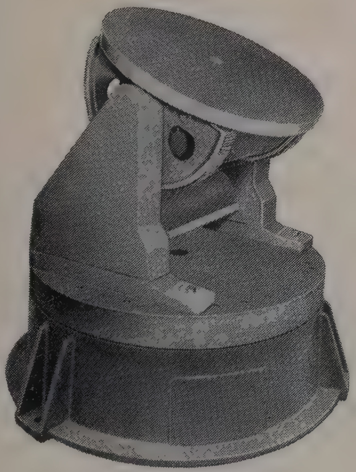
When the applied power is just below the breakdown power, breakdown can be initiated by bringing a radioactive source close to the weak point in the component. The radioactive source is usually placed at the end of a rod about a foot long, and this is moved around the outside of the component while the latter is subjected to a peak power as close to breakdown as possible. When the radioactive source is near the weak point, it will cause breakdown to occur. Although this method will not pinpoint the trouble, it will indicate the general location, and is thus useful as a first step in determining where breakdown occurs in an intricate design.

The methods described have all been used successfully. For the occasional high power measurement, the standing wave method may be used to increase power, but for continued tests, the resonant ring is recommended. In determining location, coated paper is satisfactory more than 90% of the time, but in puzzling cases, a below-cut-off tube and a radioactive source are handy accessories.

POSITIONERS

'Anchor' Antennas at Naval Postgraduate School

On the windswept beach at Monterey, California, the U.S. Naval Postgraduate School operates an antenna facility in connection with courses designed to give advanced students a broader background in antenna engineering. Recently the school made an important addition to its facility—a rugged Scientific-Atlanta tri-axial antenna positioner. Featuring extremely small deflection with maximum bending moment, this Series PAEA Positioner precisely* orients the antenna under test in all three axes of rotation. DC drive motors permit continuous speed control, and 1:1 and 36:1 precision synchros on each axis relay nonambiguous position information to the instrument shelter 400 feet away. Antenna patterns are plotted and measured by a Scientific-Atlanta receiver and recorder.



Model PAEA-23
Heavy duty tri-axial
positioner.

Before the new positioner was installed, the school was limited both as to size of antennas that could be tested and the flexibility of operation. Now, even in the face of strong winds, students can test big dishes and relatively large arrays of antennas: this particular model accepts a vertical load of 10,000 lbs. and has a bending moment capacity of 10,000 ft.-lbs. And with three axes, flexibility is virtually unlimited in taking "cuts".

Scientific-Atlanta supplies positioners with various load capacities and bending moments in a modular series of azimuth, elevation, and polarization units. Restricted axes are equipped with limit switches, continuous rotation axes can be supplied with rotary joints and/or slip rings. All axes are normally supplied with precision 1:1 and 36:1 synchros. DC, variable speed drives, or servo drive amplifiers are available.

For details, write for technical bulletin.

SCIENTIFIC-ATLANTA, Inc.
2162 Piedmont Road, N.E. • Atlanta 9, Georgia
TRinity 5-7291

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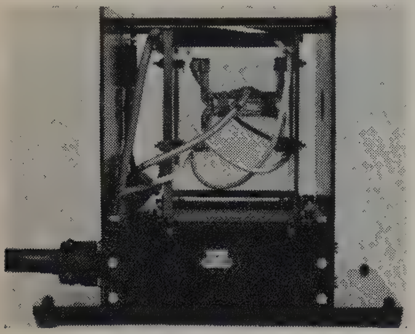
*Position Accuracy of Model PAEA Positioner at U.S. Naval Post-graduate School (degrees): Upper Azimuth, 0.04; Elevation, 0.05; Lower Azimuth, 0.03.

New Products

LIGHT SOURCE FOR OPTICAL MASER STUDIES AVAILABLE



Edgerton, Germeshausen & Grier, Inc., Boston, Mass., has introduced a new high energy, efficient, adaptable light source for optical maser studies.

The EG&G Model 511 Laser Stimulator is the result of work done by Dr. H. E. Edgerton of M.I.T. and Edgerton, Germeshausen & Grier. By developing a method to provide close optical coupling between the flash tube and the crystal, and the use of special "U"-shaped Xenon-filled flash tubes, he was able to increase the efficiency of the light source by a factor of about 10 over that of the conventional spiral flash tube.

The flashhead contains from four to 10 flash tubes, dependent on the light requirements and diameter of crystal used. Each tube is conservatively rated at 100 watt-seconds per flash. Crystals approximately two inches long and up to ½ inch in diameter can be accommodated. Tube holders can be relocated, when necessary, to increase the space between the flash tubes and the crystal, permitting forcing of a coolant around the crystal. A blower is incorporated in the flashhead for air cooling of the assembly. Flash tubes may be connected in series or in series parallel.

The flash tube assembly is enclosed in a degreased aluminum foil cover which deflects a maximum of light upon the crystal, insuring a minimum of light loss. The flashhead has provisions for tripod mounting.

Circle Reader Service Card 100

—*mwj*—

CAST WAVEGUIDE COMPONENTS OFFERED BY MICROWAVE ASSOCIATES

A comprehensive line of high quality cast waveguide components, available from stock, has been announced by Microwave Associates, Inc., Burlington, Mass.

Compensated cast bends, folded hybrid tees, E/H and straight adapters, sidewall hybrid couplers, and waveguide-to-waveguide couplers are available for use at frequencies from 1.2 to 40 kMc. Units applied in either Beryllium Copper or Aluminum are electrically and mechanically interchangeable with similar units which may now be in use.

Models are cast with aligning fences to facilitate system installation, or without fences for flange applications.

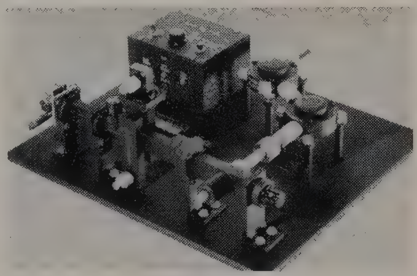
In addition to over 60 cast waveguide components available from stock, Microwave Associates will assemble these cast components to special order and will design and produce cast waveguide components to meet electrical and mechanical specifications.

Circle Reader Service Card 101

—*mwj*—

HUGHES DEVELOPS 'PARAMP' MODELS FOR FOUR BANDS

Low noise, stable, environmentally qualified parametric amplifiers for L, S, C and X-bands are now available from Hughes Aircraft Company's components division, Culver City, Cal.



One model, an S-band non-degenerate type with a noise figure of less than three db including circulator loss from −10° to +70°C, has had noise figures measured as low as 1.9 db at S-band in the laboratory with bandwidths in excess of 80 Mc at 15 db gain.

Hughes 'paramps' are designed to utilize a number of varactor diodes now commercially available from several diode manufacturers. Each parametric amplifier includes a basic amplifier body, a varactor diode, a circulator, pump power monitor, and a klystron. Available as optional equipment is a transistorized pump power supply.

Circle Reader Service Card 102

—*mwj*—

ALL-WEATHER MICROWAVE ABSORBER DEVELOPED

A resonant foam microwave absorber of the Salisbury Screen type has been developed for all-weather use by B. F. Goodrich Sponge Products, Shelton, Conn. Identified as its "RF" type absorber, the company advances features of electrical performance greater than 25 db at resonance and a bandwidth sufficient to cover a complete radar band. The material is fire-resistant and performance is allegedly unaffected by water, hydraulic fluids and aviation fuels.

Lightweight and flexible, the B. F. Goodrich "RF" absorber is of BFG "Cell-Tite" unicellular neoprene foam protectively faced for resistance to weather, abrasion and other physical damage. Of a thickness approximately 1/8th wavelength in air, it is available tuned to any wavelength from one cm to 10 cm. It is readily affixed to metal surfaces, will conform to curved surfaces and can be cut and formed to irregular shapes as cut edges do not require sealing.

Applications cited by B. F. Goodrich for its new "RF" absorber are to improve performance of radar and navigational systems by minimizing undesirable local reflections; to reduce antenna side lobe levels and to increase isolation of adjacent antennas. The company also claims the lightweight feature to be suitable for airborne applications.

Circle Reader Service Card 103

—*mwj*—

ROHN OFFERS 170-FOOT SELF-SUPPORTING COMMUNICATION TOWER

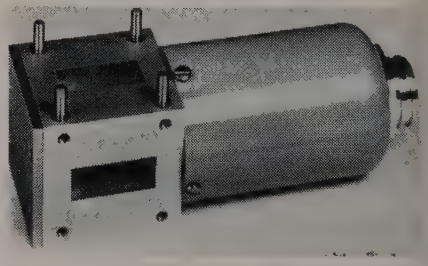
Rohn Manufacturing Co., Peoria, Ill., announces a new, 170-foot self-supporting communication tower. Prior to this time, the Rohn self-supporting line of towers had a maximum height of 130 feet.

The addition of three heavy duty 20-foot sections to the basic, self-supporting Rohn design gives the extra height and support needed to increase the rating so it can be used for bigger and heavier jobs.

Circle Reader Service Card 104

—*mwj*—

COMPACT SOLENOID WAVEGUIDE SWITCHES FEATURE HIGH POWER



An extremely compact Single-Pole Double-Throw waveguide switch for use in RG-51/U waveguide systems (7.05 - 10.0 kMc/s) is available from Microwave Associates, Inc., Burlington, Mass.

The MA-1064 switches are conservatively rated at 300 kW (kilowatts) peak power when operated unpressurized, and at 500 kW peak power when pressurized to two (2) atmospheres. Units have been

(*Continued on page 86*)

3 new Microwave Amplifiers designed by request

*** 1 watt — 12.4 to 18 Kmc**

*** 2 watts — 8 to 12.4 Kmc**

*** 5 watts — 7 to 11 Kmc**

MICROWAVE AMPLIFIER

Available now from Alfred Electronics

FEATURES

- * Rated gain and power output over each range at one setting of controls
- * 30 db gain at rated power; flat response
- * Compact, simple to operate
- * Rack or bench mounting
- * RF connectors out of front or rear

A number of Alfred's customers asked for—and now have—amplifiers with 1 and 5-watt outputs covering the ranges listed above. The new units can be used as broadband power amplifiers; stable power oscillators using external resonant feedback networks; narrowband amplifiers providing more than rated gain and power and for frequency multiplication. Each amplifier consists of a TW tube, its focusing magnet, and a completely regulated supply for obtaining optimum performance from the TW tube.

BASIC DATA	526	527	528
Frequency Range	12.4 to 18 Kmc	8 to 12.4 Kmc	7 to 11 Kmc
Power Output	1 watt	2 watts	5 watts
Gain (Small Signal)	30 db	30 db	30 db
Gain (Saturation)	25 db	30 db	30 db
VSWR (Input/Output)	2:1	2.5:1	2.5:1
RF Connectors	P Band Flange VG-419/U	Type N Female	Type N Female
Price	$4,950	$3,490	$3,490

For more information, call your Alfred engineering representative or drop a line to Palo Alto. Please address Dept. 69

ALFRED ELECTRONICS

897 Commercial Street
PALO ALTO, CALIFORNIA
Phone: DA 6-6496

9

LET'S TALK ABOUT PEDESTALS

The Greeks had a word for it, which escapes us at the moment. And we should have a better word for it, but we haven't. In this day and age, a pedestal is not a simple device to hold something up. Rather, at least in the electronics industry, it is a unique and complex portion of an antenna system.

Canoga designs, develops and manufactures rugged, reliable, light-weight, low-cost pedestals for almost any radar and telemetry, optical and infra-red use—land-based, ship-borne, on trailers, on roof-tops; for use in the arctic, in the desert or in the tropics.

Canoga pedestals are slim, minimizing wind loading and permitting the mounting of counter-balances significantly closer, thereby greatly reducing polar moments of inertia. Gear trains and related electronics are completely enclosed—providing protection from weather, fouling, corrosion, breakage, etc. Up to 810° of travel are available without slip-rings for non-rotational tracking and slip-ring models are available for all around tracking capability. (Canoga has developed the Tri-Ped antenna which provides complete flexibility by the addition of a third, or traverse, axis to the conventional azimuth and elevation axes.)

A single stowing lock secures both elevation and azimuth gears and disengages servos in one operation. Elevation of 200° permits "plunging" for boresight purposes.

Canoga pedestals offer compact, double planetary, interchangeable drive modules with eccentric backlash adjustment, modular interchangeable data packages, balanced elevation yoke which eliminates eccentric loading of the azimuth bearing, yielding increased high-elevation angle accuracy and minimizing the perpendicularity problem. Also, a synchro-torque transmitter hand-wheel follow-up feature eliminates unexpected pedestal accelerations when switching from the slaved to local mode of operation.

Canoga pedestals can accommodate paraboloidal dish antennas up to 28′ in diameter and various helix arrays.

Standard bolt circle and bolt dimensions provide for adaptability to standard mounts or mounting can be engineered to customer specifications.

Canoga Electronics Corporation also manufactures complete radar systems, microwave ferrite devices and components, radar and telemetry antennas, radar reflectors, range instrumentation, test equipment and special electronics equipment to customer specifications. **canoga**

CANOGA ELECTRONICS CORPORATION, VAN NUYS, CALIFORNIA • FORT WALTON BEACH, FLORIDA

Circle Reader Service Card 43

New Products

(*Continued from page 84*)

tested to over 400 kW peak power, unpressurized. These switches may be pressurized to 45 psig.

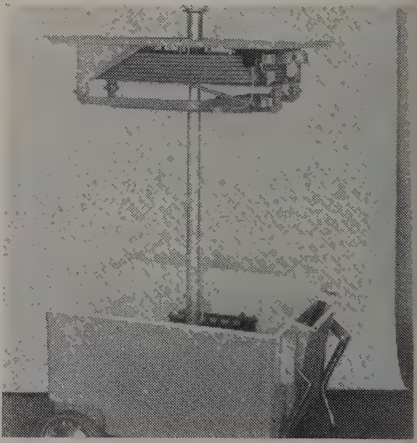
A low insertion loss of 0.15 db and a maximum VSWR of 1.10 over the entire waveguide band are important features of these switches. Isolation in excess of 35 db is achieved by optimum design of internal chokes and by precision machining.

A prime advantage of these new switches is the low holding current of 150 milliamps (ma), achieved without the use of power wasting and dropping resistors. This low holding power minimizes heating during continuous operation and allows operation at ambient temperatures up to 125°C.

Circle Reader Service Card 105

—*mwj*—

RAMP TESTER CHECKS BENDIX DOPPLER SYSTEM



A ramp tester, designed by Bendix, has been introduced to make operational checks on a complete Doppler Radar Navigation System as installed in aircraft.

In operation, the tester receives a signal from the Doppler antenna and returns it to the antenna in such a manner as to simulate a specific ground speed and drift angle, without the aircraft leaving the ground. Various altitudes can also be simulated.

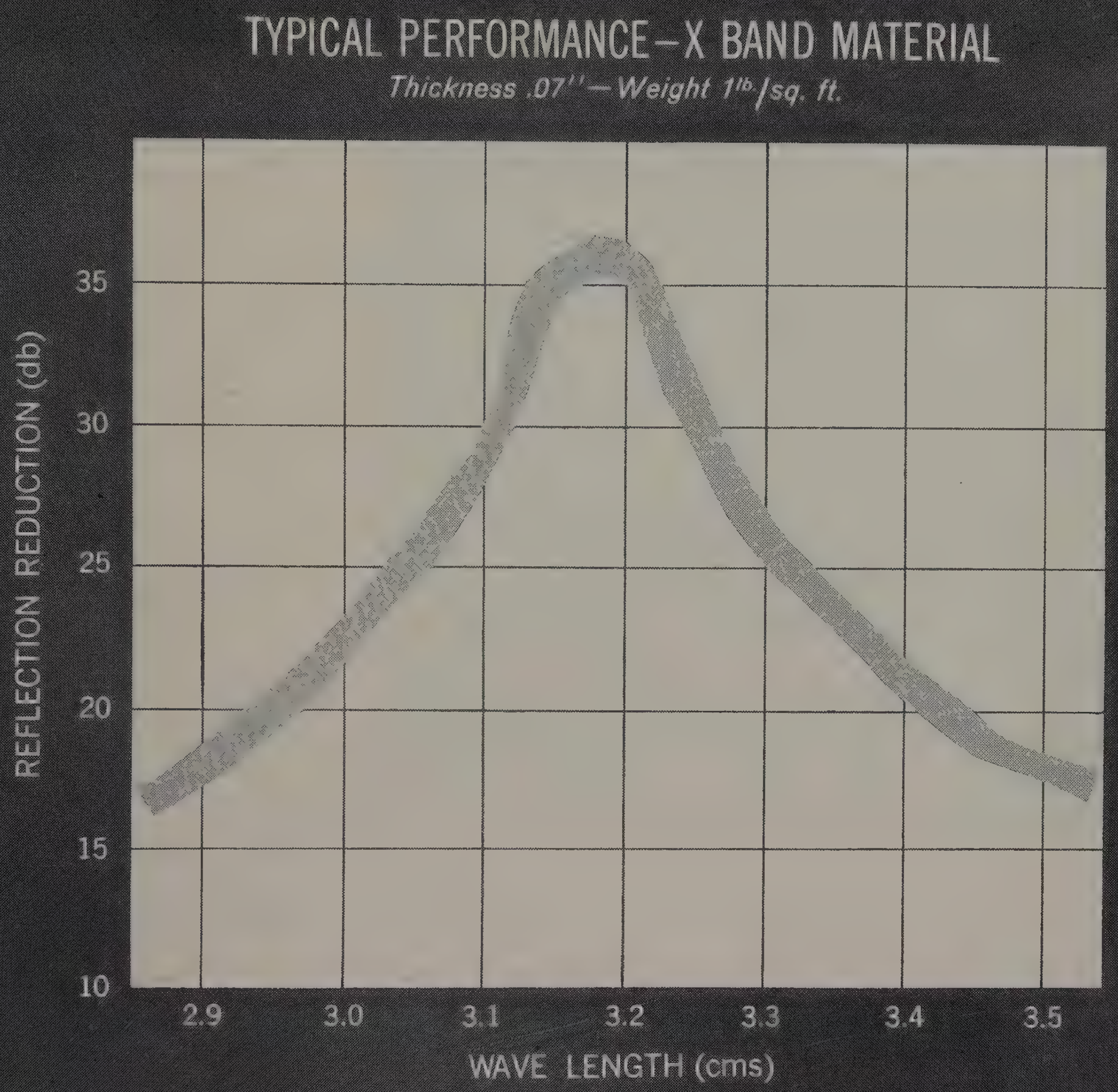
A feature of the tester is the use of a delay line specifically fabricated of 83 feet of Phelps Dodge Styroflex coaxial cable by the Electronics Division, American Tube Bending Co., New Haven, Conn. Using a polystyrene as dielectric, the outer diameter is ½ inch diameter aluminum tubing.

The delay line was wound on a rectangular form 25 feet long and 14 feet wide, and is placed in series with the waveguide assembly to present an initial simulated altitude of approximately 125 feet.

Circle Reader Service Card 106

—*mwj*—

(*Continued on page 88*)



New all-weather microwave absorber improves radar performance

. F. Goodrich develops easy-to-install resonant aterial that reduces radar-distorting reflections

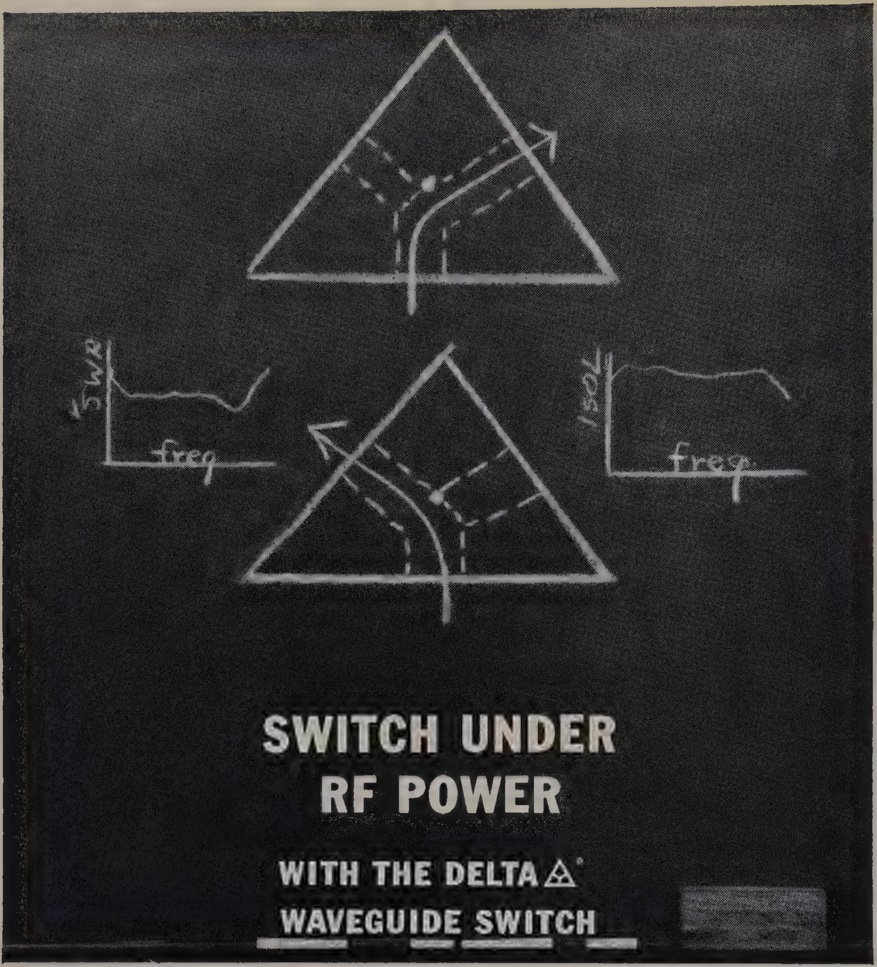
he chart shows the ability of a newly-developed resonant aterial to reduce radar-distorting reflections from nearby asts, antenna towers and other metal structures.

This B.F.Goodrich Type RS absorber is a thin, flexible lastic sheet. Easy to install. Can be cut, bent, adhesive-onded to metal objects of any shape. Ideal for outdoor se. High heat (up to 400°F.), sub-zero cold, sun, wind nd rain won't affect performance. It resists abrasion, an even be walked on.

In addition, B.F.Goodrich has also developed a number of other absorbers for accurate testing of components and systems. Included are broadband microwave absorbers, resonant types tuned to desired frequency, high temperature absorbers, and complete anechoic chambers installations. Made to military specifications where applicable, all undergo rigid lab tests prior to shipment.

For full details on the new Type RS material, or information on our other microwave absorbers, just write *B.F.Goodrich Sponge Products, 130 Derby Place, Shelton, Connecticut.*

MICROWAVE ABSORBENTS BY B.F.Goodrich



7 milliseconds switching time
7 ounces for x-band model
Operates in severe environments

A new concept in remotely-controlled microwave switching, DELTA ⚠ Waveguide Switches permit 7 millisecond switching under rf power. Control circuitry to shut down magnetrons or other power sources may be *eliminated* in many systems. Switching under rf power is possible because the switching element is a thin metal vane which acts as a power divider during the switching cycle. The benefits—LIGHT WEIGHT, RELIABLE OPERATION and MINIMUM ACTUATOR POWER.

The DELTA ⚠ W-6XA shown here is one of a complete line of rugged waveguide switches designed for reliable operation in critical environments. Write or call us or your Don-Lan Engineering Representative for complete specifications on these switches today.

actual size
(x-band)

*PATENT PENDING

Don-Lan Electronics, Inc.
a subsidiary of
Quantatron, Inc.
1131 Olympic Blvd.
Santa Monica, California
EX 3-0758

Don-Lan specializes in combining optimum microwave and electro-mechanical techniques. Consult us on your microwave electronic problems.

Circle Reader Service Card 45

(*Continued from page 86*)

SYLVANIA EXPANDS MAGNETRON LINE WITH Ka-BAND UNITS

Ruggedized Ka-band magnetrons have been made available to manufacturers of missiles and ground and airborne microwave equipment by the Electronic Tube Division of Sylvania Electric Products Inc., Williamsport, Pa.

Type XM-4218 is a lightweight (four lbs.) 32 kilowatt Ka-band (34.8 to 35.4 kMc) unit designed for missile and airborne applications including surveillance, mapping and fire control. It operates at 33,000 feet without capsule pressurization or potting compound. With a peak power output of 32 kw, the unit can withstand 10 G vibration (50-2000 cycles) and meets military environmental specifications.

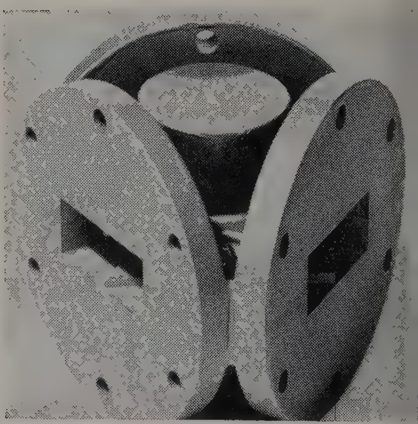
Type XM-4158 (27 lbs.) is six pounds lighter than its predecessor, the 100 kw Ka-band magnetron (Type 6799), also developed by Sylvania. With 120 kw peak power output and ruggedized construction, Type XM-4158 is ideal for airborne navigation, mapping and terrain avoidance equipment.

Type XM-4064 (nine lbs.) is capable of withstanding 20 G vibration at 54 to 2000 cps. With a peak power output of 70 kw, it offers a broad range of pulse width and duty cycle service and provides operating frequency and mode stability under severe environmental conditions. It is designed especially for airborne reconnaissance and mapping radar systems.

Circle Reader Service Card 107

—*mwj*—

HUGHES OFFERS WAVEGUIDE Y CIRCULATORS



Hughes Aircraft Company's components division, Culver City, Cal., has developed a line of new waveguide Y circulators with 20 per cent bandwidth and more than 20 decibel isolation to operate at any frequency band within the range of 2.6 to 12.4 kMc. Charles W. Curtis, division manager, has announced.

Previously, Hughes 20-20 circulators were available only for the 4.9 to 6.2 and 8.0 to 9.8 kMc ranges, Curtis said.

Specifications for the new circulators are — isolation: 20 db (minimum); bandwidth: 205 of center frequency; insertion loss: less than 0.5 db, and voltage standing wave ratio: less than 1.2.

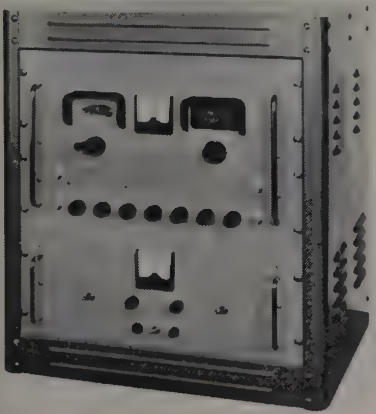
Circle Reader Service Card 108

—mwj—

MICRO-TEL ANNOUNCES HIGH SENSITIVITY MICROWAVE RECEIVER

Model MRL-100, a broad frequency coverage, highly sensitive superheterodyne receiver for cw measurements of microwave signals, has been announced by Micro-Tel Corp., Baltimore, Md. Its primary applications are for antenna pattern ranges, VSWR measurements, and other areas where sensitivity is a primary requirement.

A single local oscillator, covering the range from 900 Mc to 2100 Mc permits reception from 840 Mc to above 75 kMc by utilization of harmonics of the LO.



Minimum specified sensitivities are —90 dbm from 840 Mc to 12.4 kMc, —85 dbm to 26 kMc, and —80 dbm above 26 kMc. Receiver output is linear to within 0.5 db over a 40 db dynamic range. Two AFC systems (one electronic, one mechanical) provide automatic tuning for source jitter and for slow frequency drift of the source.

The receiver is extremely simple to operate, offers one percent direct-reading frequency adjustment, and incorporates an inexpensive klystron for low-cost LO replacement. An accessory unit extends frequency coverage from 30 Mc to 840 Mc.

Circle Reader Service Card 109

—mwj—

LOW LOSS LAMINATING RESIN ANNOUNCED

Emerson & Cuming, Inc., Canton, Mass. has announced Eccomold L-70, an extremely low loss, high temperature laminating resin. When used in conjunction with quartz or fiberglass fabric, laminates capable of 500°F are produced.

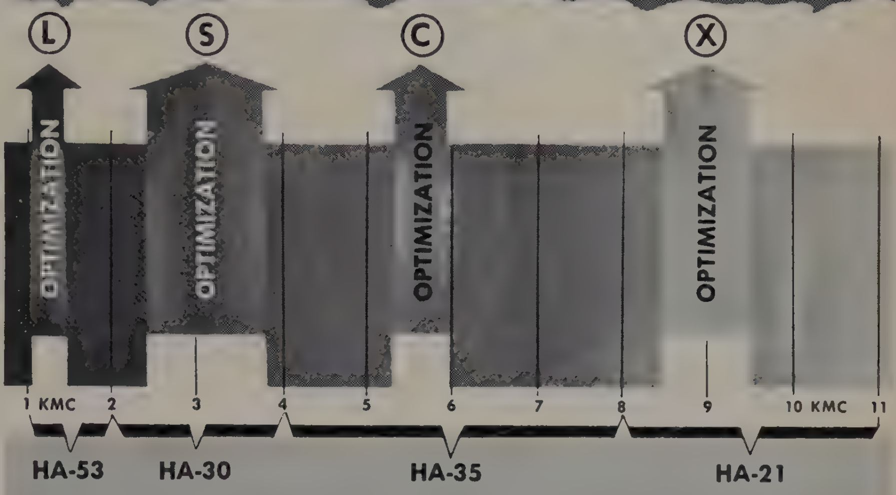
With polypropylene fabric, low dielectric constant laminates are made. These are used in radomes, printed circuit

(*Continued on page 90*)

TWT's OPTIMIZED for NARROW BAND USE

GREATER POWER OUTPUT

INCREASED SMALL SIGNAL GAIN

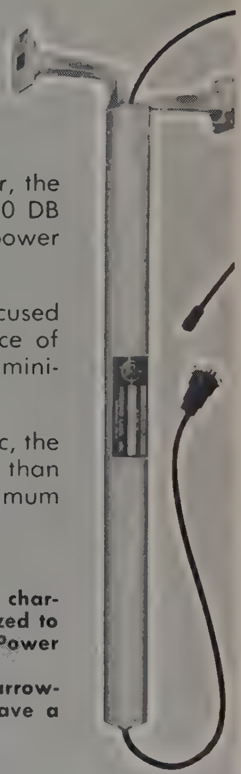


Ⓛ **1.1 - 1.4 kmc** The PPM focused type HA-53, normally operated from 1 - 2 kmc, when optimized is capable of greater than 35 DBM power output and 40 DB small-signal gain.

Ⓢ **2.4 - 3.8 kmc** Cataloged as a 2 - 4 kmc amplifier, the PPM focused HA-30 exhibits greater than 40 DB small-signal gain, with 33 DBM minimum power output over the narrow band.

Ⓒ **5.3 - 6.0 kmc** The HA-35, a 4 - 8 kmc solenoid focused amplifier, displays narrow-band performance of 32 DBM minimum power output, and 45 DB minimum small-signal gain.

Ⓧ **8.5 - 9.5 kmc** Normally operated from 8 - 11 kmc, the PPM focused type HA-21 is capable of more than 45 DB small-signal gain, and 31 DBM minimum power output when optimized.



Although the traveling wave tube is best known for its characteristics over a broad frequency range, it may be optimized to operate over a narrow band with outstanding results. Power output and small-signal gain are significantly increased.

If your system application requires a high-performance, narrow-band amplifier, contact Huggins Laboratories. We may have a TWT with the exact characteristics for your system.

HUGGINS manufacture development engineering design research LABORATORIES

HUGGINS LABORATORIES INC.

999 East Arques Avenue Sunnyvale, California REgent 6-9330

Circle Reader Service Card 46

New Products

(*Continued from page 89*)

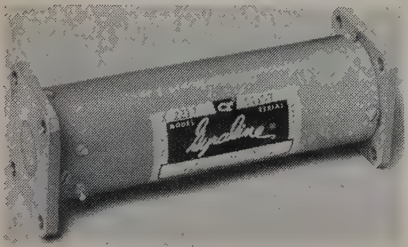
boards, waveguide windows, antenna insulators and other critical electronic applications. Eccomold L-70 is extremely simple to use. It is a one-component material; no catalyst addition is necessary. It is supplied at a viscosity which assures thorough wetting of the fabric.

The dielectric constant of a laminate made with Eccomold L-70 and polypropylene fabric K2.15 with a dissipation factor of 0.0008.

Circle Reader Service Card 110

— m w j —

X-BAND VARIABLE FERRITE ATTENUATOR ANNOUNCED



Model X2217 variable attenuator, possessing the ability to maintain greater than 30 decibels of attenuation for a constant value of current as the microwave frequency is varied, has been announced by Cascade Research, Los Angeles, Cal.

Providing an attenuation range of greater than 30 decibels over a frequency range of 10,250 to 10,500 megacycles, this unit is designed so that it can be switched from minimum to maximum attenuation in less than 20 microseconds.

Model X2217 is ideal for remotely controlling attenuation or for switching, in antenna and receiver applications. Similar models are available at other frequency ranges.

Circle Reader Service Card 111

— m w j —

METAL-CERAMIC TWT'S AVAILABLE FROM GE

Two high-power compact metal-ceramic traveling-wave tubes designed to operate as the driver and final amplifier in a pulsed high-power chain are now available from General Electric Company, Power Tube Dept., Palo Alto, Cal., for X-band radar applications.

Type Z-3090, the driver tube, covers the 8,500 to 9,600 megacycle frequency range. It has a nominal output of five kw over the entire band and has a peak power output of 10 kilowatts within the band. Power gain is 35 db, efficiency 15 per cent, and maximum duty cycle 0.005. The tube also can be used as a final amplifier in a medium power application.

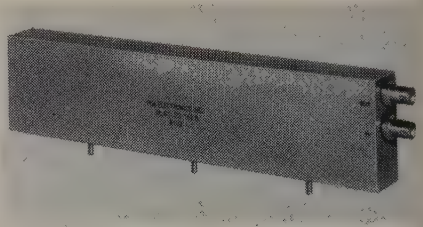
The amplifier tube, type Z-3091, covers the 8,500 to 9,600 megacycle range. It has 250 kw minimum power output over entire band and has a peak power output of 500 kilowatts within the band. Power gain is 20 db, efficiency 25 per cent and nominal duty cycle 0.004.

Circle Reader Service Card 112

— m w j —

PCA INTRODUCES BAND PASS DELAY LINE

A range of new, light weight Band Pass Delay Lines is being manufactured by PCA Electronics, Inc., Sepulveda, Cal., for incorporation in systems requiring time delay in the vicinity of a fixed center frequency — such as in radar and communication IF amplifiers.



The new delay lines are available in various combinations of operating frequencies and time delays generally restricted to ultrasonic type delay lines. Typical time delay values of .22 micro-

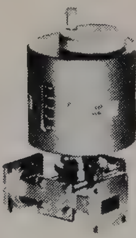
(*Continued on page 92*)

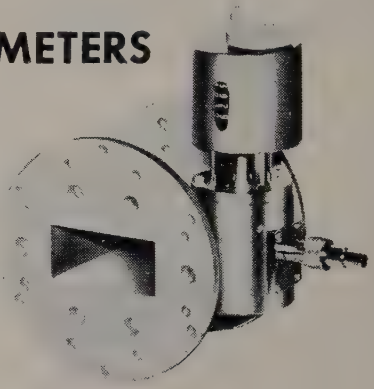
DIRECT READING FREQUENCY METERS

By means of the exchangeable coupling elements

- End-connected waveguide or coaxial
- Passing waveguide or coaxial
- Crystal mounts and lid

various circuit arrangements most suitable for the occasion, like reaction, absorption or transmission type of frequency meter can be formed by the user.

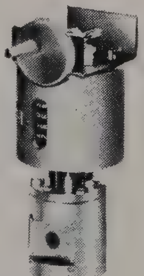




The SIVERS LAB Direct Reading Frequency Meters enable a quick and accurate determination of frequencies in the Microwave region. The frequency range from 1 kMc/s to 18 kMc/s is covered by 10 models. Each model operates over the full waveguide band, with direct reading accuracy better than ±0,1%.

Attachments are available to enable the frequency meter to be included in the interior of a rack system with the control on the front panel.

Price example: SL 5205 supplied with end-connected and passing waveguide $165.00 fob Stockholm



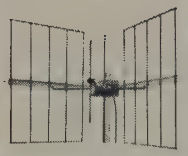
Type No.	Frequency range kMc/s
SL 7510	1,1 — 1,7
SL 5815	1,55 — 2,5
SL 5212	2,5 — 4,0
SL 5590	3,3 — 4,9
SL 5174	3,8 — 5,9
SL 7599	4,5 — 7,29
SL 5585	5,4 — 8,6
SL 7100	7,05 — 11,2
SL 5205	8,2 — 12,4
SL 7095	12,4 — 18,0

Please write for our complete catalogue.

SIVERS LAB

P.O. BOX 42018
STOCKHOLM 42
SWEDEN
CABLE: SIVERSLAB

Circle Reader Service Card 47



ENLARGED VIEW OF ONE
CORNER REFLECTOR ELEMENT

LONG RANGE REMOTE CONTROL

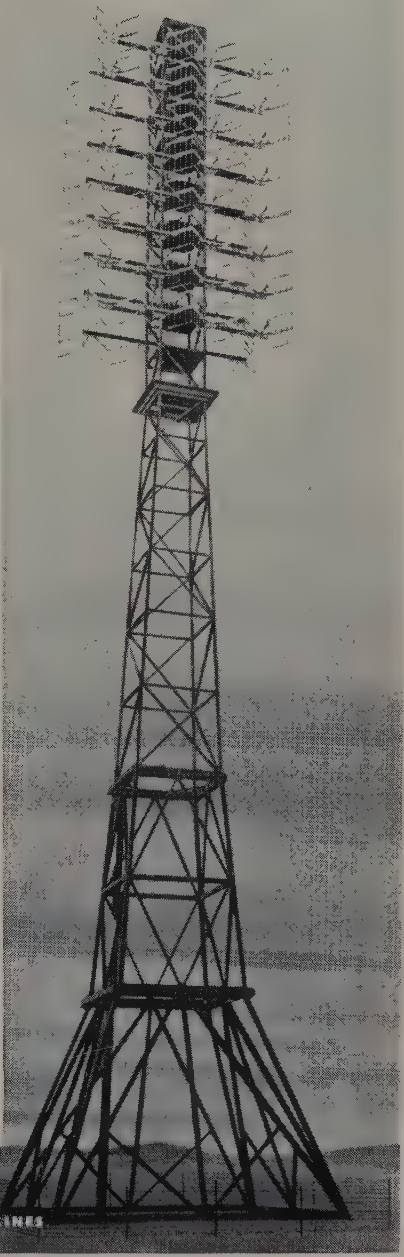
ANDREW engineers regularly solve difficult antenna problems. An example is the 32-element array recently designed for The Trans-Arabian Pipe Line Company for long range communication and control.

REQUIREMENT: A 160 mc antenna system for use at four unattended radio-controlled gas-turbine pumping units located 60 to 100 miles away from the main pump stations along 754 miles of pipeline. Minimum forward gain of 20 db over a dipole and maximum VSWR of 1.5 across 156-174 mc band were required. Existing towers dictated that the design feature minimum weight and wind loading together with maximum mechanical stability.

SOLUTION: ANDREW engineers specified, designed, and produced a rectangular array of 32 aluminum corner reflectors that met all electrical and mechanical requirements of this system for telemetry, control, and voice communication.

Installations like this demonstrate our ability to handle difficult antenna assignments. ANDREW engineers are ready to apply their know-how to your antenna system problems.

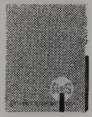
Andrew
CORPORATION
P. O. Box 807, Chicago 42, Illinois



Circle Reader Service Card 48

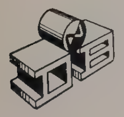
Antenna Systems, Inc., is devoted exclusively to the design, fabrication and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy, and special antenna products.

We invite your inquiry, whatever your antenna problem may be. Write for our folder.



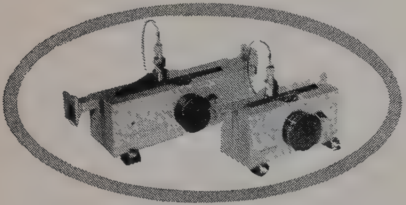
ANTENNA SYSTEMS INC.
HINGHAM, MASS.

Circle Reader Service Card 49



STANDING WAVE DETECTORS

—exceptionally accurate



You get the accuracy that results from perfect parallelism between slot and waveguide axis . . . between probe travel and waveguide axis. Only 30 seconds needed to equip a D-B slotted line to measure adjacent frequency bands. Range: 5.8 KMC to 140 KMC—covered by a *minimum* of units, to stretch your budget. Literature on request.

DE MORNAY BONARDI

DE MORNAY—BONARDI
780 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

Circle Reader Service Card 50

New Products

(*Continued from page 90*)

seconds, at an operating frequency of 60 Mc and a bandwidth of 10 Mc are attainable in a unit measuring only one inch x two inches x 10 inches.

Insertion loss is three db. Input and output are connected by means of standard 50 ohm cables terminated in BNC-type connectors. Because of these bulkhead-type connectors, and a special sealed construction, the Band Pass Delay Lines will withstand stringent environmental conditions.

Circle Reader Service Card 113

—m w j—

RUBIDIUM SPECTRAL LAMP DESIGNED FOR RESEARCH

A Research Rubidium Spectral Lamp, designed to provide the researcher with a stable, high-intensity light source for use in optically pumped resonance systems has been announced by Varian Associates, Tube Division, Palo Alto, Cal.

The lamp consists of a precise amount of alkali metal and noble gas in a transparent bulb mounted in the inductive winding of a free-running 100 Mc excitation oscillator. Model X49-609 Spectral Lamp provides a high-photon flux at a correspondingly high signal-to-noise ratio. Substantially, the only noise present in the spectral output of the lamp is the fundamental limiting optical photon shot noise of the discharge.

Potassium, cesium, sodium, and mercury discharge bulbs are available upon special request.

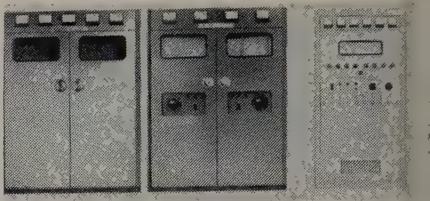
Circle Reader Service Card 114

—m w j—

PULSE DISTRIBUTED AMPLIFIERS AVAILABLE FOR HIGH POWER TRANSMITTING SYSTEMS

Granger Associates, Palo Alto, Cal., has announced a new line of high power pulse distributed amplifiers for system applications in electronic countermeasures, propagation research and ionospheric radar.

These amplifiers are available in output power levels from 10 watts to 100 kilowatts and offer power gains of up to 24 db over 16:1 frequency bands in the h-f range. According to Dr. John V. N. Granger, president of G/A, these amplifiers make frequency-independent high power transmitting systems possible for the first time. They are suitable wherever fast frequency change over extreme bandwidth without returning is essential, he said.



G/A Model 116 amplifier produces a pulse power output of 100 kw with a power gain of 22 db over the four to 32 Mc band. It is housed in two cabinets. G/A Model 126 amplifier produces a pulse power output of 30 kw with a power gain of 17 db over the four to 64 Mc band. No tuning is necessary with either model.

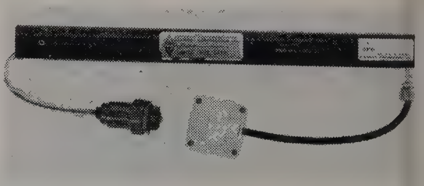
Circle Reader Service Card 115

—m w j—

COMPACT BWO PROVIDES WIDE-BAND TUNABILITY

A new high-performance backward wave oscillator, designated the Model OD 12-18, is now available from Stewart Engineering Corp., Santa Cruz, Cal. The new tube provides wide-range electronic tunability, with a minimum power output of 10 milliwatts, throughout its frequency range of 12.4 to 18 kMc.

It is designed for service in applications requiring uniform power output vs. frequency characteristics, and is thus particularly suitable for use as a signal source for microwave swept signal generators and similar electronic equipment.



The Model OD 12-18, which is guaranteed for a minimum of 500 hours of operation, is a compact design, enabling significant space economies in comparison with conventional BWOs providing the same output. The tube is a hard glass and metal, helix type high-vacuum backward wave oscillator. It is enclosed in a protective metal capsule, with an RG91/U output connector on RG55U coaxial cable. The power input cable utilizes a type PM6P hooded plug.

Circle Reader Service Card 116

—m w j—

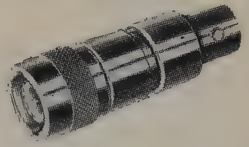
(*Continued on page 94*)

10,523 STANDARD COAXIAL COMPONENTS "ON THE SHELF"

IMMEDIATE DELIVERY FROM STOCK!

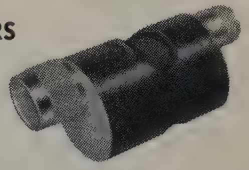
FIXED ATTENUATORS

DC to 12,000 mc
0 to 80 db
1.2 max. VSWR
2, 5, and 15 watts



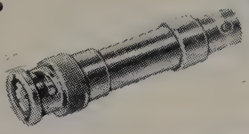
VARIABLE ATTENUATORS

DC to 10,000 mc
0 to 60 db
1.25 max. VSWR
Continuous or Turret



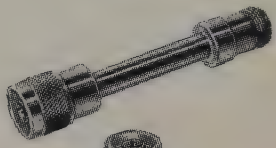
LOW PASS FILTERS

100 to 10,000 mc
1.3 max. VSWR
10 and 500 watts
Sharp cut-off.



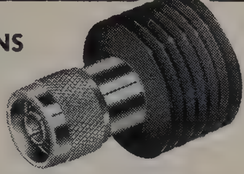
HIGH PASS FILTERS

200 to 6,000 mc
1.8 max. VSWR
10 and 50 watts
Sharp cut-off



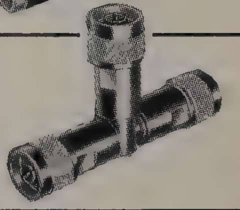
COAXIAL TERMINATIONS

DC to 13,000 mc
1.1 max VSWR
2, 10, 150 watts
Fixed and Sliding



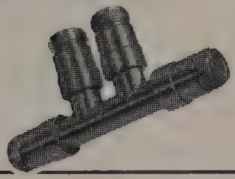
POWER DIVIDERS

DC to 10,000 mc
2 to 6 outputs
Resistive — wide band
Reactive — min. loss



DIRECTIONAL COUPLERS

200 to 4,000 mc
Full octave Bandwidth
High directivity
Uni-bidirectional

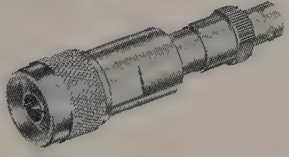


CRYSTAL MIXERS

250 to 8,000 mc
Single ended or balanced
1.5 max. VSWR
Adjustable L.O. Injection

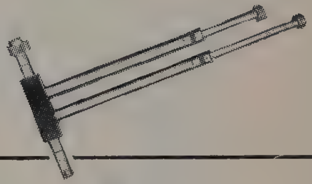
CRYSTAL MOUNTS

DC to 13,000 mc
Untuned, fixed tuned;
Padded; Tripolar
High Sensitivity



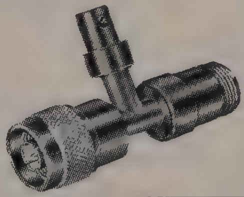
TUNERS

Stub Stretchers
Line Stretchers
Double Slug
Single, double, triple stub



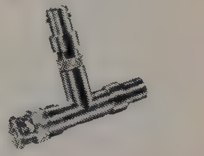
MONITOR TEES

Used to separate DC or video currents from an RF signal. Indispensable for monitoring helix intercept current in traveling wave tubes.



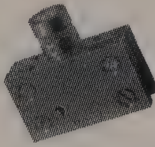
SIGNAL SAMPLERS

Used to monitor signals present in coaxial systems. Permits small signal to be taken from system without adding discontinuity. Coupling continuously adjustable.



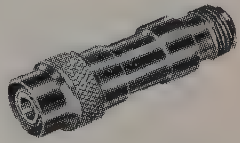
PRINTED CIRCUIT CONNECTORS

Side, end launchers
N, C, BNC, TNC
Screw-on or flange mounts.



DC BLOCKS/SHORTS

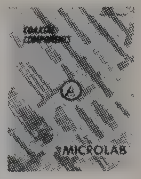
Sections of constant impedance transmission line with built-in blocking capacitor or DC by-pass.



- **All MICROLAB products are available FROM STOCK with Type N, C, HN, BNC or TNC male or female connectors.**
- **Special values, connector combinations and other special design features at same low cost and quick delivery.**
- **Prototype or production quantities at lowest cost.**

NEW CATALOG AVAILABLE

A new 72 page catalog listing thousands of stock coaxial components and product application information is now available from MICROLAB. Write on company letterhead for CATALOG NO. 10.



μ LAB **MICROLAB**

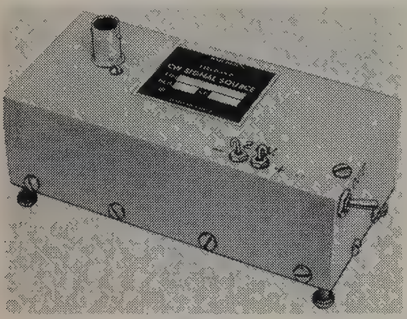
Livingston, New Jersey WYman 2-5700

New Products

(*Continued from page 92*)

UHF TELEMETERING TRANSMITTER GIVES CW SIGNAL FOR RADIO TRACKING

A UHF Telemetering Transmitter that provides an accurate and stable CW signal for radio direction finder tracking of missiles or vehicles has been announced by Frontier Electronics Co., Cleveland, O.



The TT-1001 Mod 7 is a completely transistorized CW transmitter with a self-contained, regulated power supply. Silicon transistors are used throughout. The manufacturer also states that the unit is easy to install, flexible in application and has high accuracy and stability characteristics under extreme environmental conditions.

Frequency is 225 Mc to 245 Mc. Frequency accuracy is better than 0.01 per cent, frequency stability is better than 0.01 per cent and power output is 260 milliwatts. Weight is 17 ounces with battery, 6.5 ounces without. Battery has a minimum life of one hour.

Circle Reader Service Card 117

— m w j —

MODEL 317 VOLTMETER USED AS NULL DETECTOR

Model 317 Voltmeter, which accurately measures 300 microvolts to 300 volts at frequencies from 10 cps to 11 Mc, and is useful as a null detector from 5 cps to 30 Mc, is available from Ballantine Laboratories, Inc., Boonton, N. J.

As a calibrated amplifier it provides a stable gain up to 60 db with a frequency response ±1 db from 6 cps to 11 Mc. The indicating meter has a 5 inch mirror-backed scale to make full use of the accuracy and precision of the instrument. Voltage scales of 1 to 3 and 3 to 10, each with 10 per cent overlap, are located adjacent to the mirror scale. A 0 to 10 db scale provides a ready reference for measurements in db.

Input impedance with probe is 10 megohms shunted by 5 pF, and without probe is 2 megohms shunted by 11 to 24 pF depending on range. Indication is average-responding calibrated in rms of sinewave. Power supply is 70 watts, 115/230 V, 50 - 400 cps. It is available in portable or rack models.

Circle Reader Service Card 118

— m w j —

WAVELINE ANNOUNCES WAVEGUIDE DIRECTIONAL COUPLERS

Waveline, Inc., Caldwell, N. J., announces a complete line of standard waveguide directional couplers. These precision waveguide instruments cover the frequency range of 2.60 to 40.0 kMc in a series of eight models in each of five basic design configurations. Included are cross-guide, narrow-wall and precision broad wall versions.

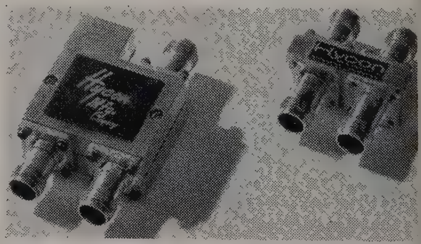
All models are available with standard values of coupling. Other electrical characteristics, such as directivity, coupling sensitivity, and VSWR are optimized over the complete waveguide frequency range. These units are manufactured of rugged brass construction with silver plating and instrument grey enamel finish.

A six-page illustrated brochure describing the design and operation of waveguide directional couplers is currently available from Waveline, Inc. Thirty-five standard couplers are described with electrical performance and mechanical dimension data, as well as a complete price list covering these stock units.

Circle Reader Service Card 146

— m w j —

HYCON DEVELOPS TWO STRIP LINE DEVICES



Hycon Mfg. Co., Monrovia, Cal., has developed two new Strip Line devices for the electronic industry.

The compact strip line precision three db coupler, weighing less than two ounces, can be used for a broad band matched power divider, a duplexer or a 90 degree phase shifter.

It consists of two broadside coupled strip transmission lines, 1/4 wave length long, and will withstand extremes of vibration and temperature since it consists of solid dielectric strip line construction.

For a typical unit centered at three kMc, length is 1.3 inches and width is .70 inch.

(*Continued on page 96*)

as low as 15^{00}*

..new UNIVERSAL "10" series

Now, J-V-M offers a new series of exceptionally rugged, economical Planar Triode Cavities for commercial and military quantity production use—the Universal "10" Series built to the same rigid standards and with the same reliable performance of the popular Mercury "10" Series.

Precision engineered

A complete range of cavities in frequencies from 220 to 4300 MC, in pulse and CW units—offering design flexibility and outstanding performance.

Planar Triode CAVITIES as oscillators, amplifiers and multipliers

*in quantity (less tube)

Send for engineering drawings and specifications

JVM
J-V-M MICROWAVE CO.
9300 W. 47th Street • Brookfield, Illinois
Phone: HUnter 5-2000
TWX: Brookfield, Ill. 2796

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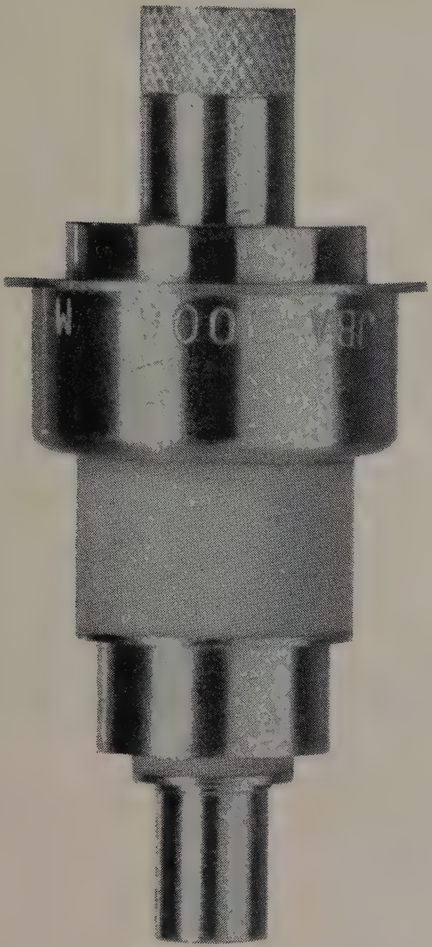


UHF

Grid Modulated

To 2000V Ebb

ML-7815

Ceramic Planar Triode

Grid-modulated to 2000V Ebb, 3.0 a ib, ML-7815 can provide a pulse width of 6 usec at a 0.0033 Du. In plate-pulsed service the ML-7815 offers similar ratings to 3500 v eb.

Unusual high voltage stability is assured (for high altitude operation) by the extended, ceramic, grid-anode insulator. The new arc-resistant nickel matrix cathode minimizes high-voltage breakdown by a factor several times that of conventional types.

Send for Machlett UHF Planar Tube Brochure

MACHLETT

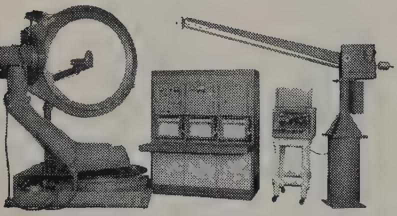
Subsidiary of Raytheon Company

The Machlett Laboratories, Inc.
Springdale, Connecticut

Circle Reader Service Card 54

Boresight Accuracy

Tested Automatically



- **Tests Type I and Type II to MIL-R-7705A(ASG)**
- **Automatically records boresight error, percent transmission, antenna patterns**
- **Accuracies greater than ±0.1 milliradian (1°/175)**
- **Test and align doppler antenna systems**
- **Flight line boresighting**

The effectiveness of the finest radar tracking system can be destroyed by the variations in refraction of the radar beam as it passes through the plastic radome. The CTI Automatic Radome Boresight-Error Measuring System assures fast, accurate measurement of the radar beam deflection as a continuous function of the antenna position. Three recorders plot the magnitudes of the horizontal and vertical error components, plus the total vector sum of the beam deflection angle, directly in milliradians. Rate of change of beam deflection angle, essential to fire control and missile applications, is readily available from the recordings. Percent transmission through the radome is measured and recorded directly. Antenna patterns are plotted with, or without, radomes. This high accuracy continuous automatic testing detects discontinuities overlooked by manual methods. The complete operation is controlled from the master console. The Model 150C, pictured here, is available for frequencies from S through K_a bands and infrared. With five years of world-wide proof of performance, the CTI Automatic Boresight-Error Measuring System is another example of CTI's advanced leadership in meeting the needs of modern electronics technology.

Write for full information and state your general application

CALIFORNIA
TECHNICAL
INDUSTRIES
DIVISION OF TEXTRON INC.
BELMONT 8, CALIFORNIA

Foremost in Automatic Testing

Circle Reader Service Card 55

(*Continued from page 94*)

Thickness excluding connectors is .312 inch, and 1.77 inches with connectors. TNC connectors are used on the standard model but type N connectors can be supplied on special order. Isolation is greater than 20 db from 2600 Mc to 3200 Mc.

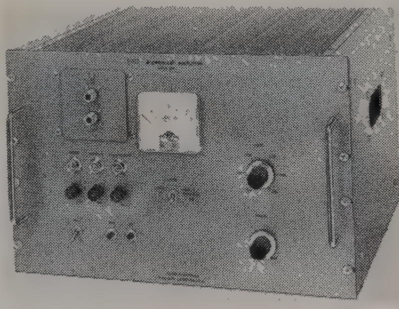
Circle Reader Service Card 119

— *m w j* —

ALFRED INTRODUCES THREE NEW AMPLIFIERS

Three new microwave amplifiers with one, two and five-watt outputs have been introduced by Alfred Electronics, Palo Alto, Cal. The one-watt amplifier covers 12.4 to 18 kMc; the two-watt unit, eight to 12.4 kMc; and the five-watt unit, seven to 11 kMc.

The three amplifiers can be used as broadband power amplifiers, stable power oscillators using external resonant feedback networks, narrow band amplifiers providing more than rated gain and power for frequency multiplication.



Compact and simple to operate, the new units incorporate these features: rated gain and power output over each range at one setting of controls, 30 db gain at rated power, rack or bench mounting, and RF connectors out of front or rear.

Each amplifier consists of a TW tube, its focusing magnet, and a completely regulated supply for obtaining optimum performance from the TW tubes.

Circle Reader Service Card 120

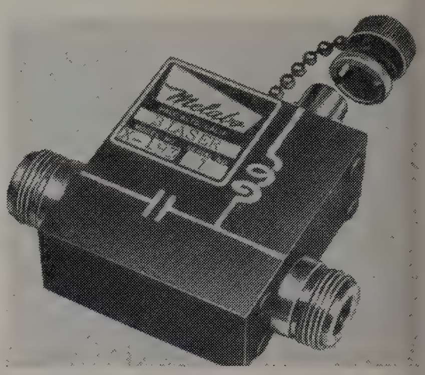
— *m w j* —

MODEL X-193 BIASER AVAILABLE FROM MELABS

The Model X-193 Biaser, a new laboratory test component with a wide variety of applications, is now available from Melabs, Palo Alto, Cal.

The biaser has a frequency range from one to 11 kMc and is useful to 0.5 kMc. Its insertion loss is less than 1.5 db and VSWR is less than 1.5. Principal applications of the instrument include the DC isolation of two components; applying DC bias to detector, mixer and variable diodes; providing DC return for a diode; video or DC and RF multiplexing, and high sensitivity detector measurements.

Minimum DC resistance between the biaser's RF terminals is one megohm. Maximum bias resistance is two ohms and maximum bias current is 250 milliamperes. Maximum voltage across RF connectors is 1000 volts.



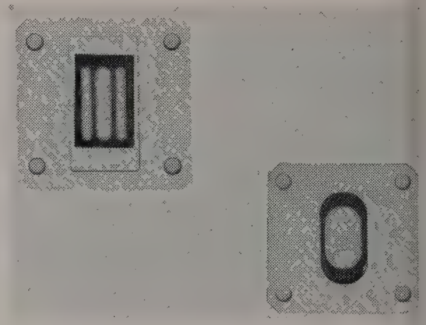
Dimensions of Model X-193, excluding connectors, are 3/4 inch x 1-3/4 inches x two inches. Connectors include a type N female (RF terminals) and a BNC type UG-1094/U with chain attached shorting cap.

Circle Reader Service Card 121

— *m w j* —

WAVEGUIDE PRESSURE WINDOWS TRANSPARENT TO MICROWAVE ENERGY

A new line of flange-type waveguide pressure windows is now available from Microwave Development Laboratories, Inc., Wellesley, Mass. These flange windows provide an air-tight seal within waveguide systems, yet are transparent to microwave energy. They maintain pressure to assure maximum performance, and prevent entry of moisture, dirt, or dust.



MDL flange-type waveguide pressure windows are designed for use with EIA waveguide sizes WR-42, WR-90, and WR-112. These windows mount between two choke flanges fitted with rubber "0" ring seals, and are silver plated to reduce r.f. loss.

Circle Reader Service Card 122

— *m w j* —

(*Continued on page 98*)

UP to 150 KMC at –45 VOLTS BV!

WITH NEW SYLVANIA SDV-4166

EPITAXIAL SILICON VARACTOR

DIODE

Through the use of epitaxial techniques, SYLVANIA has proven the practicability of manufacturing Silicon Varactors with cutoff frequencies as high as 150 KMC at a 45-volt breakdown voltage. As an indication of the significance of this Sylvania development, previously available diodes made with conventional techniques and with equivalent breakdown voltage exhibit cutoff at less than 15 KMC at –6 volts.

Capacitance values of the new Varactors are as low as 0.15 pf at –6 volts. They are ideally suited for service as harmonic generators with exceptional power handling capabilities. Conversion efficiency in doubler circuits at L-band is approximately 70%. Units are hermetically sealed in compact Sylvania Micro-Min packages and double-ended cartridges that offer extraordinary reliability and performance at high temperature.

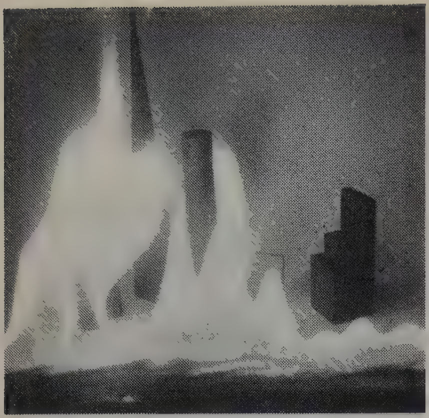
For the complete story on how SYLVANIA EPITAXIAL SILICON VARACTOR DIODES can help upgrade the performance of your microwave equipment, contact your Sylvania Sales Engineer now. Semiconductor Division, Sylvania Electric Products Inc., Woburn, Mass.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM



WHEN IS
AN ABSORBER
AN ABSORBER?

When it's a symbol on the drawing board . . . a sample under test . . . a finished product?

The same question can be asked about a dielectric material, a ferrite, a core.

The answer: any microwave or rf attenuator is satisfactory only when it fulfills the requirements of the system.

As our name implies, Custom Components is more than a manufacturer of attenuator materials. We are a facility that translates the performance specifications of your system into specific materials, shapes, weights and sizes.

When is an absorber an absorber? When your attenuation problem becomes our attenuation problem!

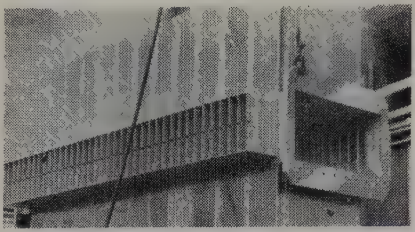
CUSTOM COMPONENTS, inc.

P.O. Box 248, Caldwell, N.J.
CApital 6-3404

New Products

(*Continued from page 96*)

HARMONIC ABSORPTION FILTERS DEVELOPED



General Electric Company's Power Tube Department has announced availability of seven new high-reliability harmonic absorption filters for high-power microwave transmitters with fundamental frequencies in ranges from 400 to 6,000 megacycles. These were developed at the department's Traveling-Wave Tube Product Section, Palo Alto, Cal.

These filters, ruggedly constructed to combine carefully designed passive circuit elements and mechanical features for long-life service, are designed to absorb unwanted harmonic power signals at UHF and microwave frequencies, thus eliminating numerous interference situations created in recent years by such signals from high-powered radar equipment.

They also provide increased fundamental power handling capability in the waveguide transmission line by overcoming waveguide breakdown problems prevalent in equipment generating harmonic power.

In normal applications, the filters are located in the waveguide transmission line between the output tube and the antenna, and as close as possible to the output tube.

Six of the filters, covering the S-, C-, L- and UHF bands, are relatively small and lightweight, while the seventh filter — in the UHF range — is believed to be the largest built to date.

Circle Reader Service Card 123

— *m w j* —

VARACTOR DIODES DEVELOPED THROUGH EPITAXIAL TECHNIQUES

Microwave silicon varactor diodes, with cutoff frequencies as high as 150 kMc at minus 45 volts breakdown voltage, have been developed through epitaxial techniques by Sylvania Electric Products Inc., Semiconductor Division, Woburn, Mass.

Marvin E. Groll, product sales manager — microwave diodes of Sylvania's Semiconductor Division, said the high Q, high breakdown voltage diodes exhibit frequencies as high as 100 kMc and capacitance values as low as 0.15 pf at minus six volts. Diodes manufactured with conventional techniques have cutoff frequencies below 15 kMc at minus six volts.

As harmonic generators, the new devices feature exceptional power handling capabilities, according to Mr. Groll. "In preliminary tests as doublers at L-band, they show conversion efficiencies as high as 70 per cent," he said.

Circle Reader Service Card 124

— *m w j* —

TUNNEL DIODE AMPLIFIERS COVER OCTAVE BANDWIDTHS AT UHF

Low noise, broadband tunnel diode amplifiers, designed and manufactured by Micro State Electronics Corp., Murray Hill, N.J., are capable of covering octave bandwidths at UHF frequencies.

The noise isolation property of this hybrid coupled tunnel diode amplifier permits realization of a very low noise figure (3.5 db). The OTA 250 operating from 250 to 500 Mcs, is suitable for applications in broadband systems requiring improved performance.

Micro State broadband tunnel diode amplifiers can be used with conventional TWT and vacuum tube amplifiers in the UHF region to further reduce the total systems noise figure and thereby improve system sensitivity.

Circle Reader Service Card 125

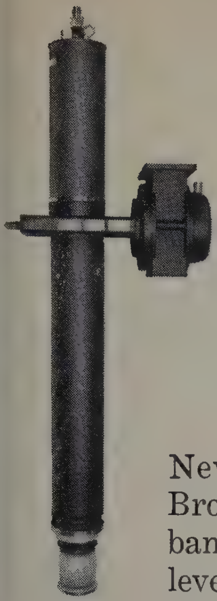
— *m w j* —

KLYSTRON MODEL LKC-5 FEATURES LIGHT WEIGHT

Lewis and Kaufman Electronics Corp., Tube Division, Los Gatos, Cal., introduces Model LKC-5 Klystron, a single cavity oscillator featuring high efficiency, light weight, and no magnetic field requirements.

Employment of a "one way" electron beam eliminates hysteresis problems common to reflex type Klystrons. As the electron beam never returns to the cathode, mechanical and thermal damage is eliminated, greatly increasing tube life.

(*Continued on page 107*)



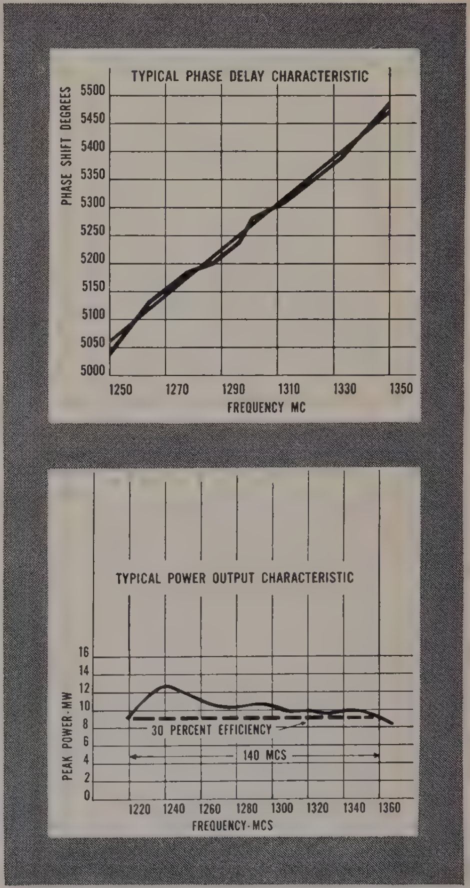
New Broadband Klystrons

140 MEGACYCLES - (1db) BANDWIDTH AT L-BAND
10 MEGAWATTS - PEAK POWER OUTPUT

New additions to the Litton Industries Broadband Klystron family extend broadband performance to even higher power levels as shown in the typical performance curves to the right. These tubes, like all those produced by Litton Industries, are conservatively designed and rated; and rigorously processed to provide many thousands of hours of reliable operation. Using Litton developed broadbanding techniques, it is now possible to achieve wide bandwith, high peak and average rf power output and linear phase shift versus frequency characteristics simultaneously. This latter feature enables the radar equipment designer to utilize pulse compression techniques to attain improved system performance.

Litton Klystrons providing these outstanding performance characteristics can be supplied in both the L and S-bands at peak rf power levels ranging from 2 to 20 megawatts. Typical of the performance obtained with Litton Klystrons is that of the L-3035, a 2.2 megawatt L-band Klystron, whose average operating life in field service is approaching 3,000 hours. Some of these tubes are continuing to provide excellent service after having operated for more than *17,000* hours.

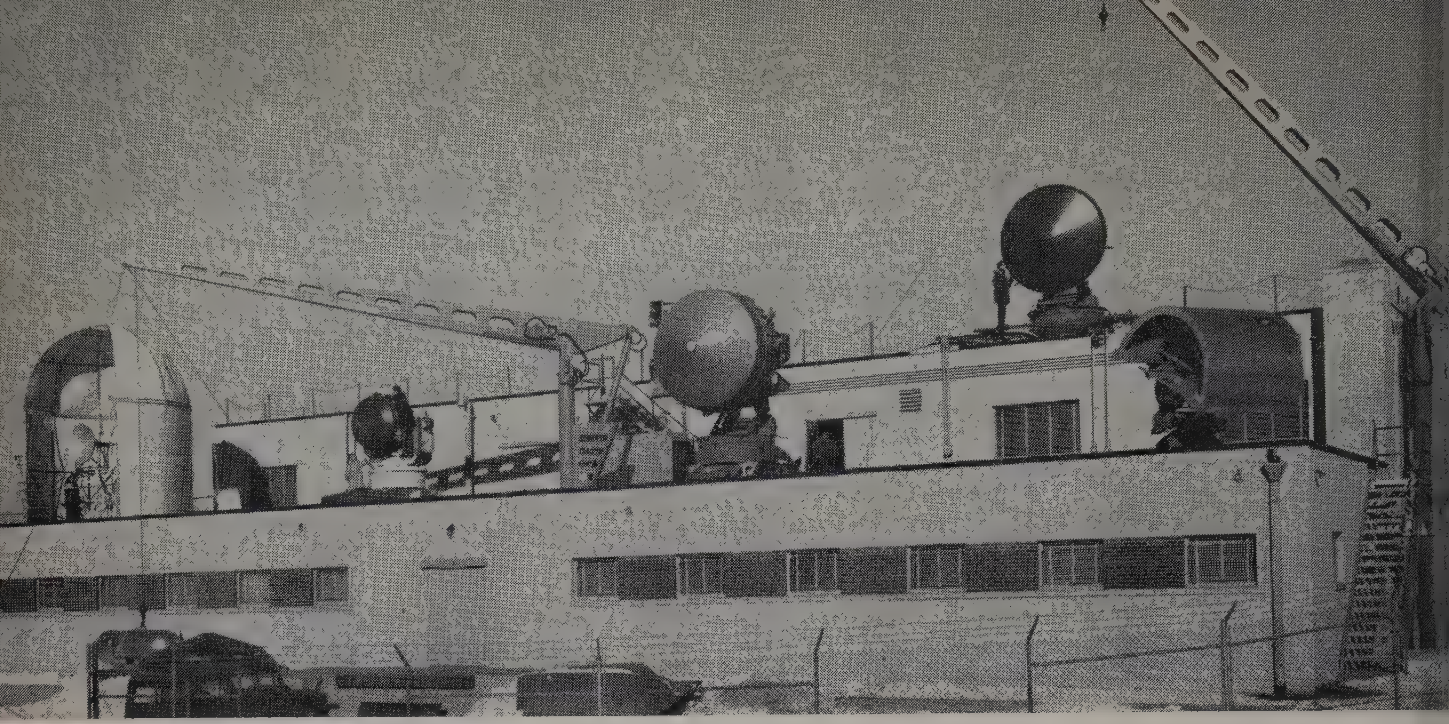
Should you require high power broadband amplifier tubes to satisfy your system requirements, please write to us at Litton Industries, Electron Tube Division, 960 Industrial Road, San Carlos, California. Our telephone number is LYtell 1-8411.



LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

"Capability that can change your planning"

Circle Reader Service Card 57



A view of the rear of the antenna development laboratory at Smithtown, Long Island, showing four of the five precision mounts now in use in testing various tracking, missile guidance, and communications antennas. The hydraulically operated cranes facilitate handling of large antenna models; the windscreen provides shelter when needed during critical tests.

COMPANY PROFILE

WHEELER LABORATORIES

Great Neck, New York

Consultation and Development

When Harold A. Wheeler * formed his own laboratory in late 1946, it was his intention to offer engineering services to the electronics industry. He saw the need on the part of many companies for the occasional services of a group of engineering specialists, a group which each company would find it difficult to support alone on a continuous basis. That the need existed and that Wheeler's idea was sound is proven today by the existence of a flourishing organization whose entire engineering staff is occupied in consultation and development for dozens of industrial clients throughout the East. Wheeler Laboratories essentially serves as an extension of the client's staff, working in close coordination with the client's engineers.

This emphasis on engineering services brings with it several interesting corollaries. One is fairly obvious: production is sidestepped because it means entering into competition with one's clients. Another corollary is that WL offers no mechanical design services; reasoning that mechanical design is inextricably wedded to manufacturing techniques and to field experience, WL works closely with the client's designers, but confines its consulting and development efforts to electrical problems.

Still another outgrowth of the services concept is WL's advocacy and use of the time-and-materials formula in charging for its work, both for Government contractors and for commercial clients. Offering the maximum of flexibility and economy, this formula is ideally suited to the pioneering activities in which WL is chiefly engaged. It permits the client to direct as closely as he chooses each phase of a given project, to change course or add assignments freely, and to halt the effort abruptly if need be.

Mr. Wheeler's lifelong background and interest in radio led naturally to increasing specialization in high-frequency techniques. The main efforts of WL today are concentrated primarily on microwave antennas and components, but include a variety of other radio problems. Interestingly enough, the very first design task undertaken led, through a series of progressive steps, directly to the largest project now under way at WL.

An Example—Microwaves for Nike

In 1946 Wheeler's embryonic facilities were saturated by an order from Bell Telephone Laboratories to design a high-power rotary joint for use with the T-33 anti-aircraft radar system, closely followed by several other microwave component developments. The successful completion of these tasks, and the mutually satisfactory client relationship evolved, led to the assignment a year later to develop the entire tactical plumbing assembly for the Nike Ajax monopulse tracking radar.

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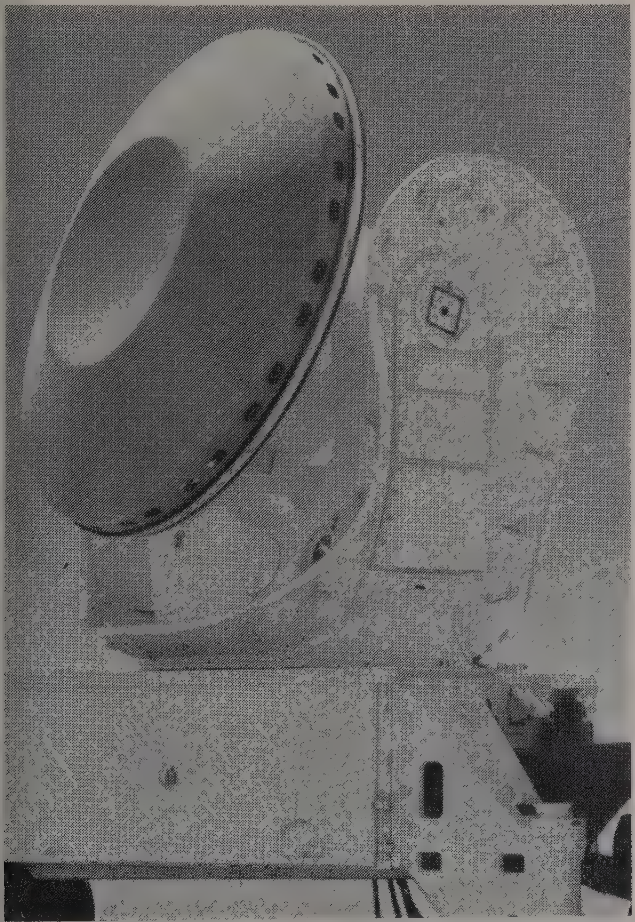
* *Microwave Journal, Sept. 1960, p. 10.*

Monopulse was an uncharted field at the time, and major contributions were made not only in designing the special components needed, but in gaining understanding of the basic principles and limitations of the technique. When the time came for BTL to develop the Nike Hercules missile interceptor system as a replacement for Ajax, WL was asked to provide the entire RF design of the track antenna. In a timely "invention-made-to-order" effort, Peter W. Hannan devised a new type of Cassegrain antenna, which set a new standard for wideband, high-accuracy tracking.

The first tremors of the Nike Zeus anti-ICBM system to reach WL came in the form of a request to provide consultation to BTL engineers on large Luneberg antennas. Then in rapid succession other areas of development were subcontracted to WL, until currently WL bears the major responsibility for the electrical design of each of the five types of ground antennas, as well as the ultimate missile antennas. Needless to say, a large fraction of the engineering group is involved in this program.

History

After 22 years of fruitful association with Hazeltine Corporation, Harold A. Wheeler left in 1946 to become an independent consultant and soon thereafter formed his own laboratory. He found quarters on the second floor of an old firehouse in Great Neck, Long Island, and hung out his shingle as a consulting physicist.



The Cassegrain antenna for Nike Hercules, shown without radome.

HAROLD A. WHEELER
CONSULTING RADIO PHYSICIST
OOR

Harold A. Wheeler hangs out his shingle, 1946.

In 1947, he was joined by three others, all with Hazeltine experience, who have since played an important role in the company. One was David Dettinger, who was instrumental in building up the engineering staff and currently serves as Executive Vice President and Chief Engineer. Another was Albert C. Paskevich, presently senior foreman of the two model shops. The third was Patricia A. Loth, the only woman engineer in the company, whose work in the Nike projects has made her an expert in monopulse theory and practice.

As the staff grew, larger quarters were needed, and in 1949 Wheeler Laboratories moved into its own building in Great Neck. In this same year Frank H. Williams, now Assistant Chief Engineer in charge of the Great Neck laboratory, joined the staff.

As Wheeler Laboratories was drawn further into antenna development work, the need arose for a special laboratory with an antenna test range. A 12-acre plot in Smithtown was acquired and a building erected. Ned A. Spencer, who had supervised a variety of development tasks since joining the company in 1948, was put in charge. The planning of this facility was done by Frederik S. Van Davelaar, who serves as mechanical consultant to the whole staff, in addition to his continuing planning functions. Other outstanding men among the engineering group include Peter W. Hannan, who is an antenna consultant as previously mentioned, Henry W. Redlien, Jr., also an antenna specialist, and Henry L. Bachman, an RF circuit expert; these men, like all others mentioned, have been with Wheeler over ten years.

The year 1959 saw the reception of Wheeler Laboratories into the expanding Hazeltine family, adding the specialized experience of WL to the diversity and resources of Hazeltine Corporation, which has been pioneering progress in electronics since 1924. Among the important contributions of Hazeltine have been advances in radio, TV, radar IFF (Identification, Friend or Foe), airborne and ground radar, underwater detection, and air traffic control. Dr. Reinhard K. Hellmann of Hazeltine Research Corporation became a Vice President of Wheeler Laboratories, providing coordination with the parent company. At the same time, Mr. Wheeler was elected to the Board of Directors of Hazeltine Corporation, thereby renewing an association which had begun in 1924.

Staff

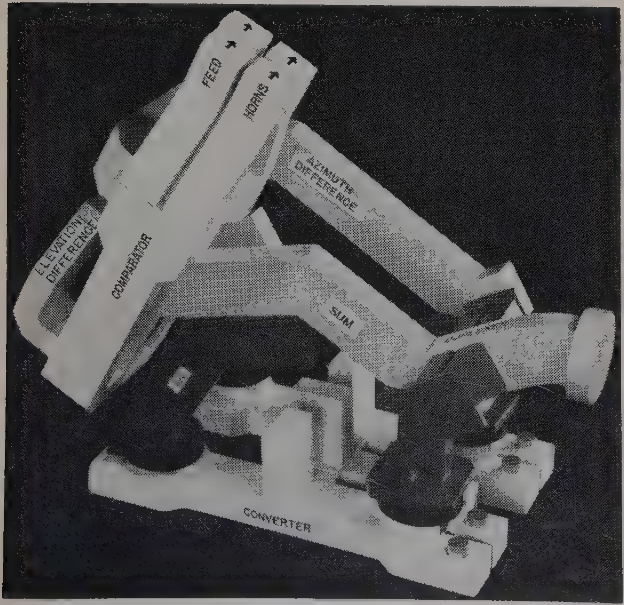
Of the entire staff of 80, half are graduate electrical engineers or physicists, representing a dozen different universities. With a few exceptions, they have been recruited directly from college through an unusually selective interviewing process. Many have completed Masters degrees; others are engaged in obtaining them from the several nearby graduate schools, principally Polytechnic Institute of Brooklyn. Each has profited from Wheeler Laboratories' informal training program, in which each new man is assigned to work directly with an experienced engineer in a small group on a particular project.

The supporting personnel fall into several categories: machinists, technicians, draftsmen, maintenance men, accountants and secretaries. Each member of these groups works directly with the engineers on an informal basis, contributing to the overall atmosphere of congeniality and efficiency.

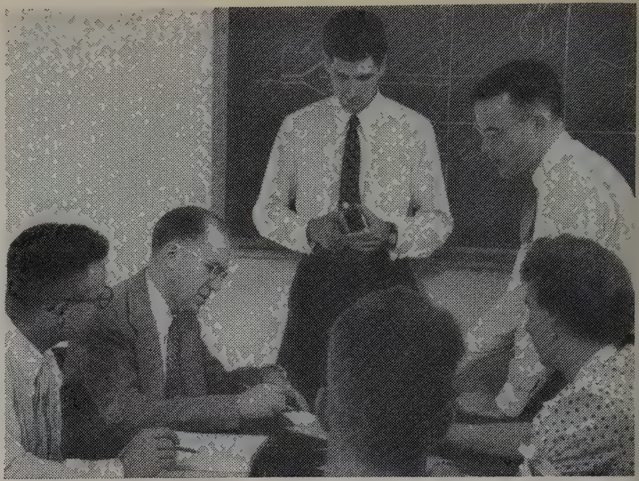
A modest program of company-sponsored extra-curricular activities operates year-round. About once a month all Wheeler Laboratories engineers attend an engineering seminar addressed by a member of the staff, or occasionally an outside speaker; these seminars introduce new ideas and developments arising out of the work of the laboratories. Several social events each year help to keep the staff a close-knit organization. Staff engineers are also unusually active in professional affairs, particularly in the IRE Long Island Section and PGMTT.

Facilities

Both of Wheeler Laboratories' two locations on Long Island provide well-planned facilities for development engineering. Each laboratory is housed in an attractive, air-conditioned building, complete with shop, technicians, drafting and offices.



Mockup of monopulse plumbing for Nike Ajax track radar.



Harold Wheeler confers with senior engineers. Left to right are: Henry W. Redlien, Mr. Wheeler, Ned A. Spencer, David Dettinger, Patricia A. Loth and Frank H. Williams (back to camera).

The Great Neck laboratory serves as the headquarters of the company, in addition to providing laboratory space for half of the engineers. It enjoys a convenient location with respect to major airports and to Manhattan.

The Smithtown laboratory occupies 12 acres of ground further out on the North Shore. Its special feature is a 1000 ft. antenna range across a valley between the main building and a source tower; the equipment at the source tower can be operated and adjusted by remote control from within the main laboratory building. The facilities include five versatile and precise antenna mounts, complete with automatic recorders and special hydraulic cranes to make testing and handling as quick and reliable as possible.

Highlights of Experience

Of the many technical specialities of WL, several have already been mentioned, such as monopulse techniques, Cassegrain tracking antennas, and Luneberg lenses. Others include microwave filters, RF transmission lines, vehicular communications antennas and flush-mounted antennas.

Mr. Wheeler's recognized position in network and filter theory has been the foundation for a succession of microwave filter designs. Some served as preselectors in radars and missiles; one has the function of suppressing spurious radiation from a radar transmitter which would otherwise jam a transcontinental microwave relay link. Another interesting design is an unusual multiplexing filter which serves to separate an X-band signal into narrow contiguous channels, to sample these channels, and then to recombine any selected channel signals in the output.

In the area of RF transmission lines, WL is frequently called on as a consultant on components such as coaxial cables, rigid coaxial lines, jumbo-sized waveguide and low-reflection waveguide runs for many companies.

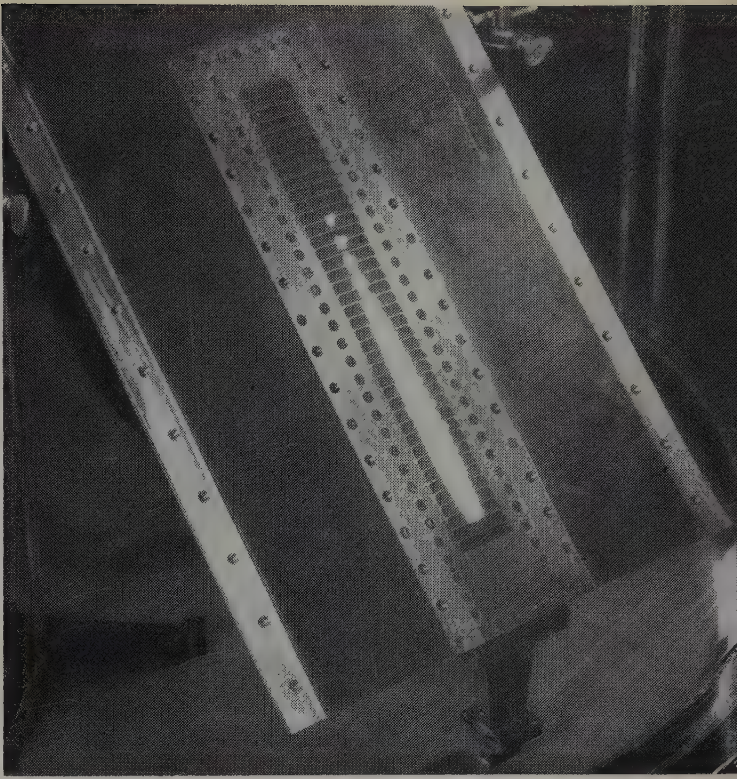
For one of its long-time clients, Communication Products, Inc., WL has developed a varied line of vehicular and base-station communication antennas. One was a ovel vertical array fitting inside a long fiberglass tube, old in thousands by the client. Another is a UHF mono- ole antenna giving a unidirectional pattern with a deep ull to the rear.

Missile-borne antennas are another specialty. Here a najor WL contribution beyond the actual design of the ntennas themselves has been in developing graphical echniques for analyzing the coverage requirements in erms of gain and polarization versus missile attitude, nd then displaying the performance achieved on the ame coordinates. The design trend has naturally been oward flush-mounted antennas. Antennas designed by VL have played an essential role in the guidance of such nissiles as Titan and Thor-Able reentry vehicles and in he succesful orbiting of Tiros, Transit, and Echo; in ach case the ground guidance antenna has also been a VL design.

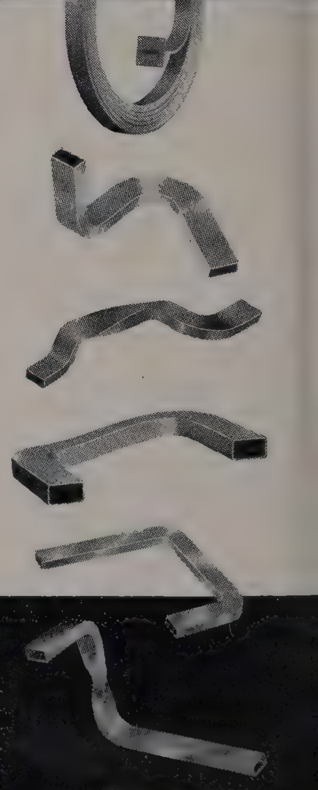
Still other areas in which WL has made important ontributions include scanning antennas, radomes, VLF ntennas, RF amplifiers and microwave breakdown. Among WL's many clients, beyond those already men- ioned, are Sperry, Sylvania, Phelps Dodge, Westing- iouse, Bendix, General Electric, and RCA, to name only few.

ooking Ahead

Over a period of 14 years, Wheeler Laboratories has leveloped with its clients a unique relationship, offering ts services for consultation and development in a wide ariety of RF problems on a direct and informal basis vhich has proved remarkably productive. The staff has grown steadily in number, but has retained the flexibility nd efficiency characteristic of a small company; at the ame time it enjoys the advantages accruing from associa- ion with the engineering and financial strength of Hazel- ine Corporation. The reputation of WL among microwave engineers attests to the competence of its individual staff members. In the years ahead Wheeler Laboratories expects to continue its program of gradual planned expansion, offering its engineering services wherever they are most needed, with the objective of making the maximum contribution to the industry and to the nation's defense.



Flush-mounted missile antenna undergoing power tests at reduced pressure to simulate high altitude.



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In 1947 Specialty Automatic was first called upon to help solve intricate and complex waveguide bending problems. Since then it has rapidly become one of America's leading suppliers of waveguide bends. With its advanced techniques and rigid quality control, Specialty Automatic will continue to assure satisfaction in your every waveguide bending requirement.

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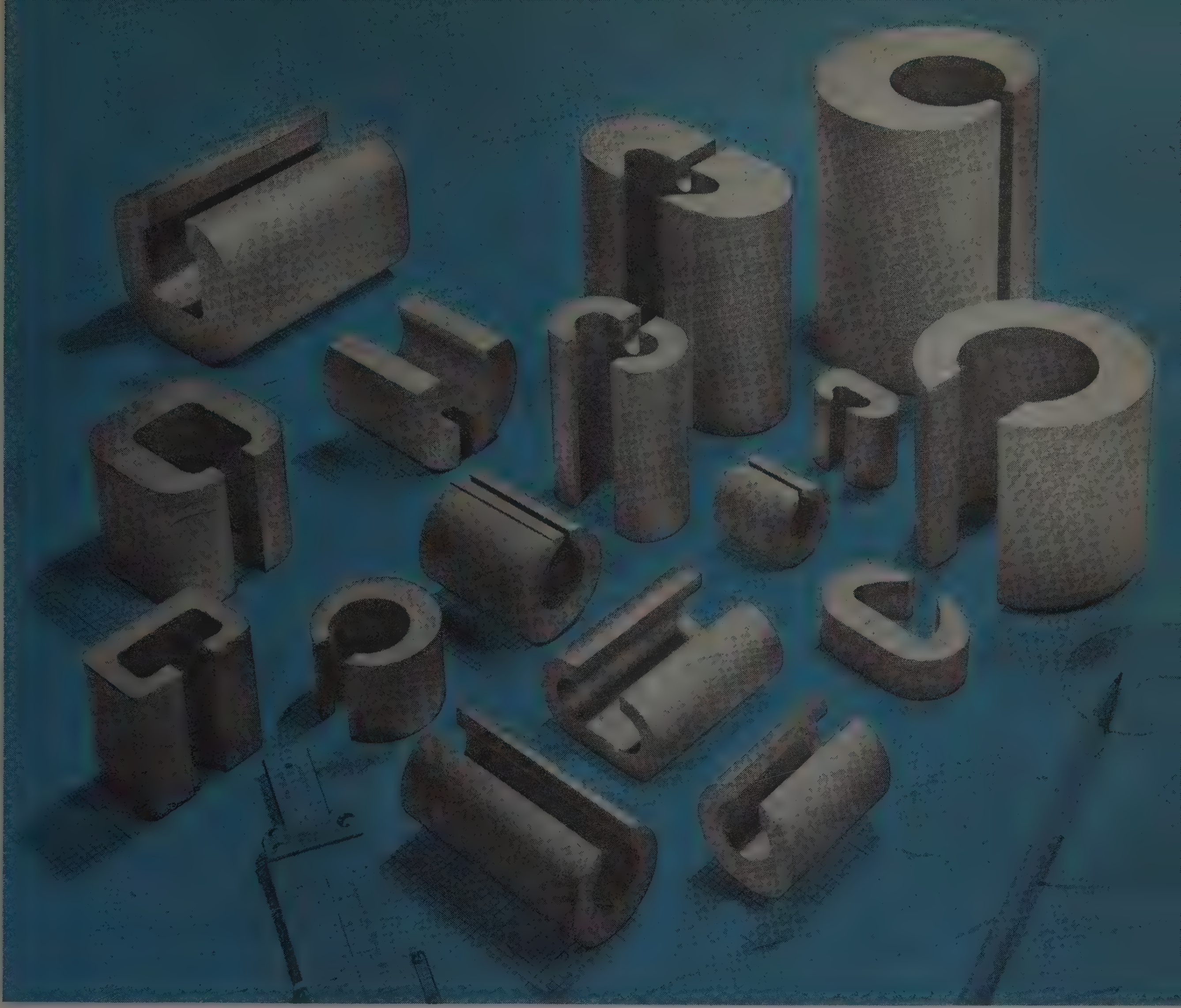


ARNOLD C-TYPE MAGNETS FOR MICROWAVE APPLICATIONS

Arnold C-type Alnico Magnets are available in a wide selection of gap densities ranging from 1100 to over 7500 gausses. There are six different basic configurations with a wide range of stock sizes in each group, which will meet the overall size and gap density requirements of many prototype designs.

Versatility in design may be realized by using multiple lengths of the same size magnet stacked to

- **Transverse Field Isolators**
- **Differential Phase Shifters**
- **Duplexers**

accomplish the needs of your magnetic structure. A number of the more popular sizes of Arnold C-type magnets are listed below and on the next page.

SIZES OF ARNOLD C-TYPE ALNICO MAGNETS

DWG.	TYPE	WT. LBS.	W	H	L	GL	GW	T	C	APPROX. GAUSSES IN GAP
9151-2	A	.22	29/32	7/8	2.50	.500	5/32	.22	5/16	1100
9537-2	A	.82	2-1/8	1-1/4	2.50	1.005	1/4	.38	23/32	1200
8759-3	A	.40	1-9/32	29/32	2.00	.501	1/4	.34	3/8	1600
8974-3	A	.54	2-1/8	1-1/4	1.56	.660	1/4	.38	11/16	1600
9354-2	A	.87	2-1/8	1-1/4	2.50	.754	1/4	.38	11/16	1700
9156-2	A	.353	2-1/4	1-7/16	.70	.502	5/32	.50	13/16	1900
7961-4	A	.86	2-1/8	1-1/4	2.50	.660	1/4	.38	11/16	1900
9008-1	A	4.09	3-3/8	3-1/4	3.00	1.250	5/8	.81	1-27/32	1900

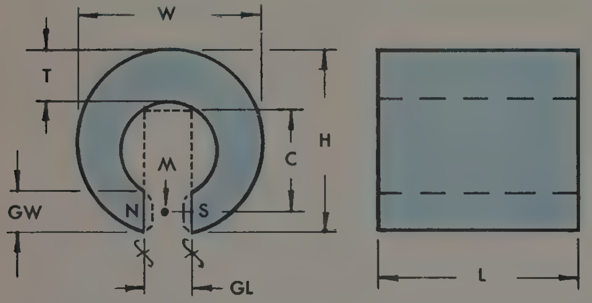
CONTINUED ON NEXT PAGE

SIZES OF ARNOLD C-TYPE ALNICO MAGNETS (continued)

*THESE MAGNETS HAVE STEEL POLES

DWG.	TYPE	WT. LBS.	W	H	L	GL	GW	T	C	APPROX. GAUSSES IN GAP
8756-1	A	.49	1-3/4	1-3/4	1.30	.518	1/4	.46	1	2200
8243-7	A	3.33	2-11/16	2-5/8	2.75	.981	9/16	.62	1-7/16	2200
8009-2	A	.57	1-1/2	1-1/2	2.00	.493	1/4	.47	11/16	2300
8678-1	A	.17	1-3/16	1-5/32	1.00	.305	1/4	.30	11/16	2300
8628-2	A	.86	1-1/2	1-7/16	3.00	.500	1/4	.48	23/32	2400
8609-3	A	3.94	2-13/16	2-13/16	4.00	.981	5/8	.75	1-7/16	2400
8895-2	A	.72	1-3/4	1-3/4	1.92	.510	1/4	.47	15/16	2500
8185-2	A	1.96	2-5/8	2.40	2.375	.750	.375	.62	1-7/16	2500
8897-1	A	6.12	3-1/2	4-1/2	2.50	1.010	5/16	1.62	2-3/8	2500
*7961-4	A	.86	2-1/8	1-1/4	2.50	.400	3/32	.38	11/16	2600
9335-1	A	.74	1-3/8	1.27	3.00	.380	1/8	.43	21/32	2700
8493-2	A	2.11	2-7/8	2-19/32	2.30	.751	1/4	.68	1-19/32	2700
8277-6	A	3.25	2-7/8	2-11/16	3.50	.790	3/8	.65	1-21/32	2700
8892-1	A	6.25	4-7/16	3-3/4	2.50	1.005	5/16	1.40	1-7/8	2800
*8588-2	A	.39	1-1/2	1-1/2	1.25	.298	1/4	.47	3/4	2800
8757-2	A	2.24	2-1/2	2-7/32	2.88	.628	1/4	.71	1-3/16	2900
8535-2	A	8.15	4-11/32	4-1/16	3.50	1.00	5/16	1.12	1-1/2	3000
7926-1	A	4.28	3-1/8	2-13/32	3.70	.751	7/32	.81	1-13/16	3200
*8971-3	A	2.58	2-5/8	2-11/32	3.00	.556	1/4	.62	1-7/16	3200
*7558-3	A	2.51	2-5/8	2-13/32	3.00	.496	1/4	.62	1-7/16	3600
*8727-1	A	3.31	2-5/8	2-13/32	4.00	.500	1/4	.63	1-7/16	3900
8109-1	A	2.12	2-5/8	2-13/32	2.50	.496	5/16	.62	1-1/2	3900
8937-3	A	2.24	2-5/8	2-1/8	2.50	.441	1/4	.87	1	4100
8735-4	A	.61	2-1/16	1-15/32	1.25	.298	1/4	.62	11/16	4300
8894-1	A	2.10	4	3-3/8	1.00	.395	3/16	1.37	1-3/4	4700
9481-1	A	1.30	2-1/16	1-15/32	2.50	.155	1/4	.62	11/16	7400
8581-1	A	.28	1-1/4	1-7/32	1-1/4	.093	1/8	.47	5/8	7700

TYPE A



W = overall magnet width
H = overall magnet height
L = overall magnet length
GL = gap length
GW = gap width
T = thickness across back of magnet
C = waveguide clearance inside of magnet

GL is usually ground to a tolerance of ± .010″ or closer. All other dimensions and surfaces are as cast, not ground.

Field is specified at the center of the gap at M half way along magnet length L.

The field uniformity at the center of the gap (M), for magnets without pole pieces, will usually be within 10% over the central three-fourths of the magnet length. Better uniformity may be obtained by using steel poles fastened to the magnet pole faces, or incorporated in the waveguide wall.

Let us work with you on any requirement for permanent magnets, including high coercive force Alnico VIII for TWT focusing applications.

For general information on Arnold products, write for Bulletin GC-106C. For data on Alnico VIII, ask for Bulletin PM-119.

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CLEVELAND, OHIO: The Arnold Engineering Company, 8905 Lake Ave., OLympic 1-1242
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ROCHESTER, N. Y.: Brace-Mueller-Huntley, Inc., 315 Hollenbeck St., COngress 6-6560
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SEATTLE, WASH.: The Arnold Engineering Company, 3327 White Henry Stuart Building, MUtual 2-2297
SYRACUSE, N. Y.: Brace-Mueller-Huntley, Inc., Thompson Road, P.O. Box 1340, HOward 3-3341
WASHINGTON, D. C.: The Arnold Engineering Company, 1001 Fifteenth Street, N. W., EXecutive 3-3775

CANADA: AJAX, ONTARIO: Bayly Engineering Limited, First Street, (Toronto Exchange) 925-2126

Export

NEW YORK, N. Y.: Sylvan Ginsbury, Ltd., 8 West 40th Street, LOngacre 4-7585

(*Continued from page 98*)

Readily scaled for operation at frequencies from 800 to 13,000 megacycles depending on customer requirements — these tubes require only one adjustment to fix oscillation frequency.

With a maximum height of 1.70 inches, and net weight of 5 ounces, the LKC-5 performs in any operating position. The Model LKC-5 Klystron is well adapted to telemetering, doppler radar and navigation, relay links, and other microwave communication system applications. Delivery approximately five weeks after receipt of order.

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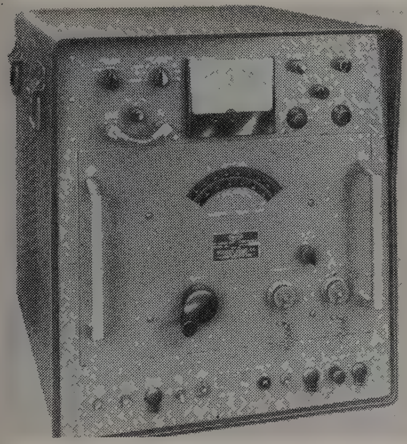
—*mwj*—

TUNING HEAD MODEL DEVELOPED FOR MICROWAVE RECEIVER

Polarad Electronics Corp., Long Island City, N. Y., announces the development of a new plug-in tuning unit for use with their Microwave Receiver Model R. The Model RE-T's frequency range is from 45,300 Mc to 84,200 Mc having a sensitivity between —50 dbm to —65 dbm. This new unit enables the Model R Receiver to be used from 400 Mc to 84,200 Mc.



To obtain the frequency coverage and high sensitivity, Polarad has designed a set of mixers incorporating integral crystals and an efficient local oscillator coupling mechanism. A single front panel Unidial® tuning knob automatically tracks the local oscillator and a linear frequency-dial accuracy. Rugged castings are used to mount electro-mechanical components, to assure long life and reliable operation.

Circle Reader Service Card 127

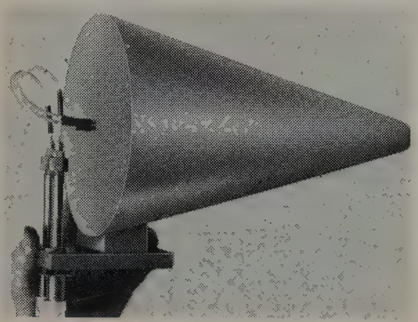
—*mwj*—

LITTON ANNOUNCES NEW BROADBAND ANTENNA LINE

A new line of broadband antennas has been announced by the Maryland Division of Litton Systems, Inc., Beverly Hills, Cal.

These antennas can be useful in such applications as transmitting antennas for antenna pattern ranges, satellite tracking, and electronic countermeasures.

Vertical, horizontal, left-circular, and right-circular polarizations can be provided in bandwidths of 10 to one or greater. The beamwidths and gain of these antennas are essentially constant across the entire operating band.



Models now available are model 12E1-10, which covers the frequency range of 100 to 1000 Mc with a gain of eight ± one db and a maximum VSWR of two to one; and model 13E1-5, which covers the range from 1000 to 5000 Mc with a gain of seven ± one db and a maximum VSWR of 2.2 to one.

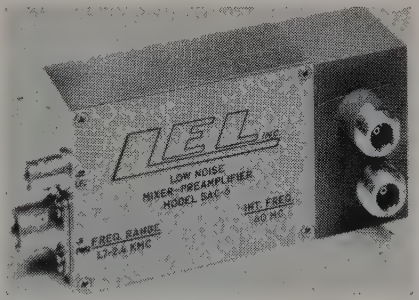
Circle Reader Service Card 128

—*mwj*—

MICROWAVE MIXER-PREAMPLIFIERS OFFERED BY LEL

LEL, Copiague, Long Island, N. Y., announces two complete new series of coaxial and waveguide mixer-preamplifiers. These series, one fully solid-state, the other employing nuvistor tubes, provide a low power drain complement to the widely accepted LEL line of matched microwave mixer IF preamplifiers. Models available from stock cover the frequency range from 1 to 36 kMc.

These latest additions to LEL's mixer-preamplifier line offer a combination of low noise, low power requirements, low weight and small size coupled with extreme reliability and ruggedness. Typical specifications follow: Nuvistor and transistor types — frequency ranges one to 36 kMc. IF output 30, 60 to 70 Mc, bandwidth 8 Mc, gain 20 db. Typical noise figures for transistor types — 10.5 db; for nuvistor types — 7.5 db.



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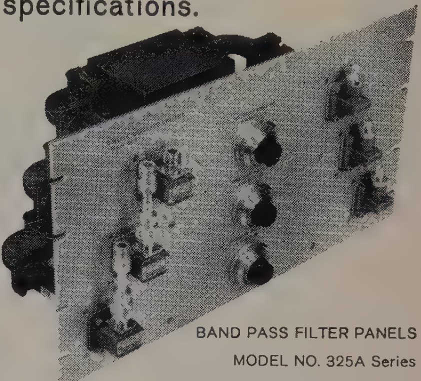
(*Continued on page 109*)

MAX-IMUM
MINIATURIZATION

ACF ELECTRONICS MICROWAVE EQUIPMENT

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.



BAND PASS FILTER PANELS
MODEL NO. 325A Series

Frequency Range: 250 MC through 20.0 KMC
Tuning Range: Minimum 10% of operating frequency*
Bandwidth: 8 MC min. ± 15% variation over tuning range**
Insertion Loss: Commensurate with bandwidth requirements
Tuning: Single knob
*Available with calibrated dial
**Bandwidth and selectivity can be modified to meet customers' requirements

Standard designs modified to meet specific requirements. Complete manufacturing and engineering facilities supported by expert field service.

There's an ACF Electronics microwave component to meet requirements in L, S, C or X-Band Frequencies.

ACF RADAR BEACONS are in a majority of orbited satellites and major missile programs.

For information or prices write or call:

ACF ELECTRONICS
DIVISION OF ACF INDUSTRIES
Paramus Plant, Paramus, N. J.
Telephone: COlfax 1-4100

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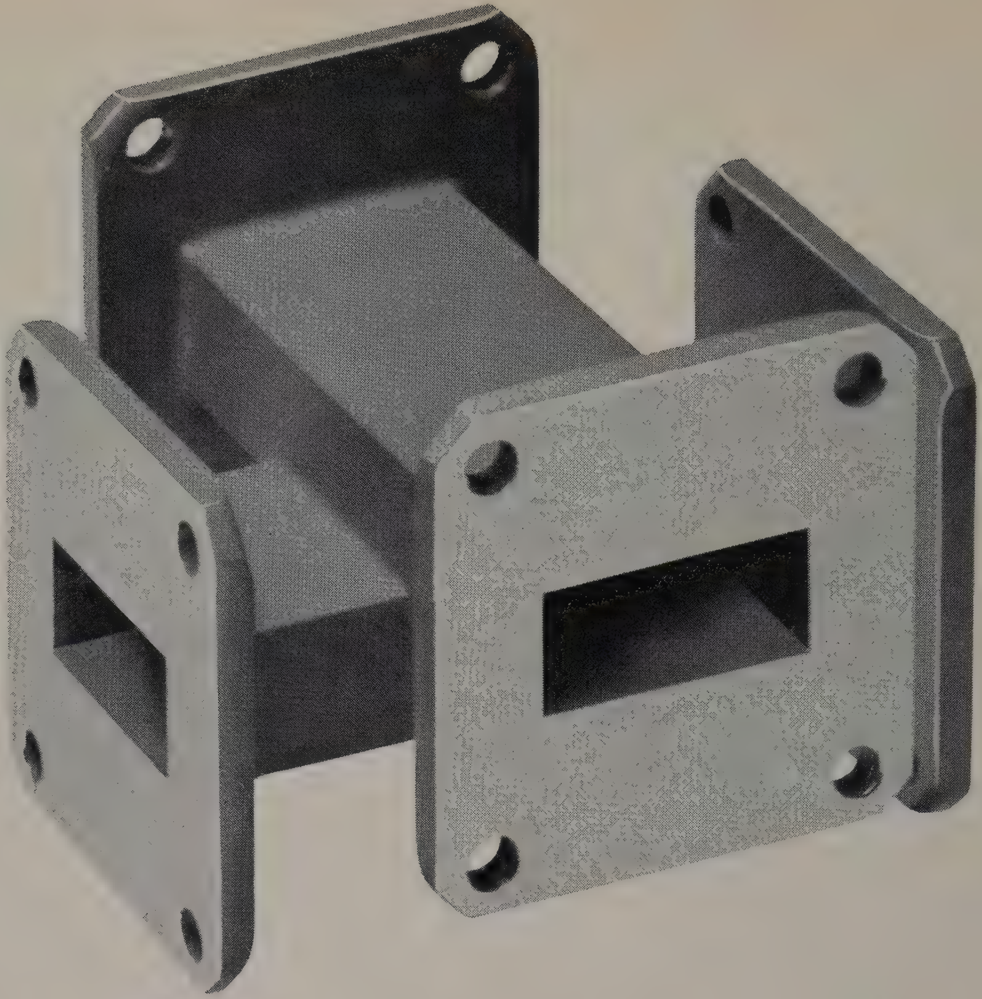
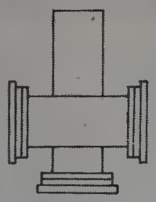


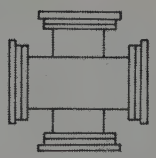
DIRECTIONAL CROSSGUIDE COUPLERS

- Very low coupling variation vs. frequency.
- Each coupler covers entire band within each frequency range.
- High directivity.
- Low VSWR.
- Compact construction.
- Available pressure-tight on request.

AVAILABLE IN 2 STYLES



3 flanges and load termination



4 flanges

FREQUENCY RANGES	COUPLING
8.2-12.4 kmc (WR-90)	All available in choice of 20, 30, 40, and 50 db coupling
6.6-10.0 kmc (WR-112)	
5.4-8.2 kmc (WR-137)	
3.95-5.85 kmc (WR-187)	
2.60-3.95 kmc (WR-284)	

Write for new technical catalog

Microwave Development Laboratories, Inc.
15 Strathmore Road • Natick Industrial Center • Natick, Massachusetts
OLympic 5-1400 — CEdar 5-6252

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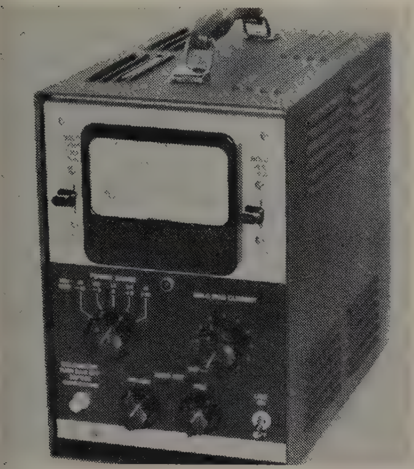
(*Continued from page 107*)

MICROWAVE POWER METER AVAILABLE

General Microwave Corp., Farmingdale, N. Y., announces the availability of the Type 451 Microwave Power Meter. The instrument is designed to operate with a wide variety of 100 and 200 ohm, positive or negative temperature coefficient bolometers (e.g., barretters, thermistors and fuses).



Five scale ranges with full-scale readings of 0.1, 0.3, 1.0, 3.0, and 10 milliwatts are provided. Corresponding decibel scales are —10, —5, 0, +5, and +10 dbm. Higher power levels may be measured using auxiliary calibrated attenuators or directional couplers.

Frequency range is dependent only on the external detector; bias current to 16 milliamps is provided; accuracy is held to within ± five per cent of full scale reading; input power requirements are 115/230 volts ± 10 per cent, 50-1,000 cps.

Circle Reader Service Card 130

—mwj—

DEHYDRATING AIR SUPPLY UNIT AVAILABLE FROM KAHN

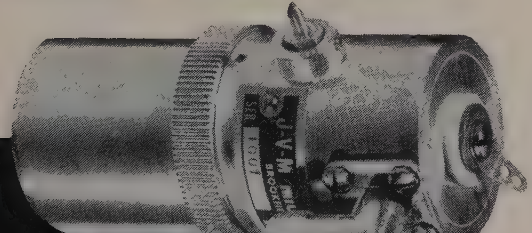
A new concept in dehydrator design and operation has been developed by Kahn and Co., Inc., Hartford, Conn., and utilized in a dehydrating air supply unit now available. This dehydrator, Model KC-1114, is particularly suited for such applications as pressurizing transmission lines and radar wave guides and purging electronic components.

Dry air output is continuous; desiccant reactivation is accomplished by a dry air purge; no heater is necessary which means longer desiccant life; better performance and no heater power required. Controls are automatic.

Kahn and Company has supplied small, compact units (19 inches high x 20 inches wide x 12 inches deep) capable of drying 100 degrees F saturated input air to —44 degrees C dewpoint with an oil-free output flow of 50 cubic in./min. at

(*Continued on page 111*)

NEW! THE MERCURY "10" SERIES
TRIODE CAVITIES



10% tuning range

Fully standardized line for design and production . . . Frequency range from 225mc to top existing tube limits

DELIVERY—30 DAYS OR LESS!

Only JVM offers these outstanding engineering advancements—low cost standardized production—off-the-shelf availability—design flexibility and uniform performance.

Miniaturized MERCURY "10" cavities are precision engineered for restricted tuning range, minimum weight-frequency stability and temperature compensation. The "10" series includes 720 different cavities designed for maximum power and/or voltage ratings of a variety of tubes.

Call or write for engineering drawings and specifications.

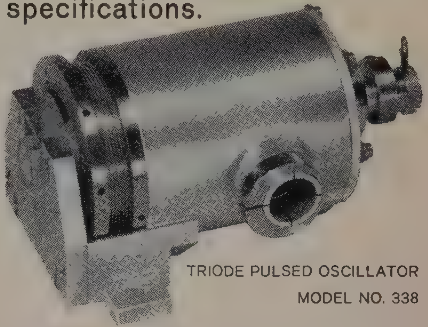
J-V-M MICROWAVE CO.
9300 W. 47th Street Brookfield, Illinois HUnter 5-2000
TWX Brookfield, Ill. 2796

Circle Reader Service Card 61

MAX-IMUM
MINIATURIZATION

ACF ELECTRONICS C-BAND MICROWAVE COMPONENTS

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.



TRIODE PULSED OSCILLATOR
MODEL NO. 338

Specifically designed for transmitter service in missile and drone type Radar Beacons.

Frequency Range: 5400 to 5900 MC

Power Output: 1000 watts; peak

Stability: ± 3 MC over all military environmental conditions

Pulling Factor: Less than ± 2.5 MC for 1.5 VSWR, all phases

Pushing Factor: Less than 5 MC/amp of anode current

Load Variation: Can withstand VSWR's of 6:1 at any arbitrary phase without impairing life expectancy

Complete manufacturing and engineering facilities supported by expert field service.

There's an ACF Electronics microwave component to meet requirements in L, S, C or X-Band Frequencies.

ACF RADAR BEACONS are in a majority of orbited satellites and major missile programs.

For information or prices write or call:

ACF ELECTRONICS
DIVISION OF ACF INDUSTRIES
Paramus Plant, Paramus, N. J.
Telephone: COlfax 1-4100

Circle Reader Service Card 62

Cast Waveguide COMPONENTS

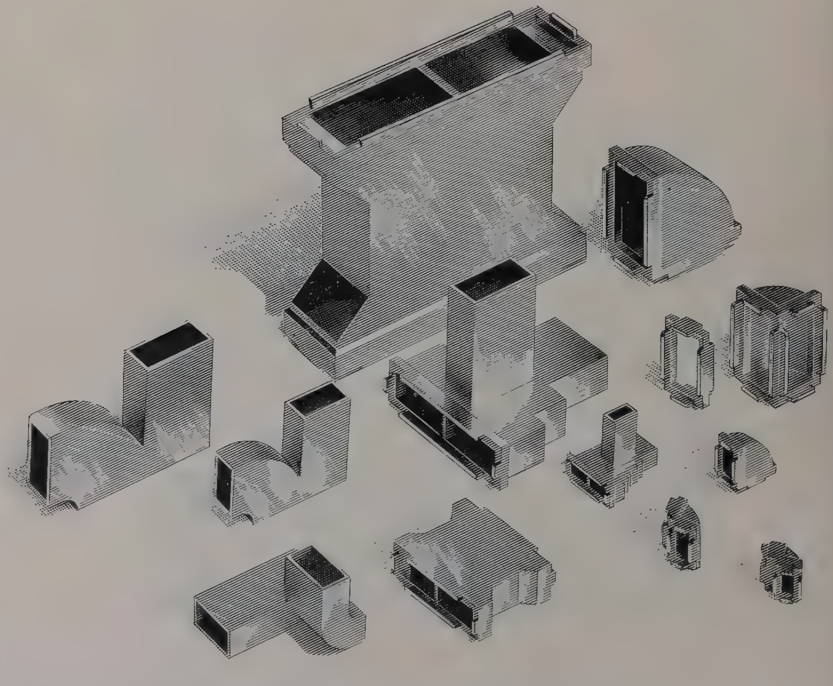
A complete line of high quality cast waveguide components is now available from Microwave Associates, Inc. Units for use at frequencies from 1.2 to 40 kMc are electrically and mechanically interchangeable with similar units you may now be using. • Delivered from stock, they may be specified in either Beryllium Copper or Aluminum.

MICROWAVE ASSOCIATES, INC. Component Division

BURLINGTON, MASSACHUSETTS • BROWNING 2-3000 • WESTERN UNION FAX • TWX: BURLINGTON, MASS. 942

Microwave Associates' Components Division also manufactures over 750 waveguide components. These include pressure windows, test equipment, specialized waveguide components such as balanced mixers, harmonic multipliers, and complete microwave sub-system packages.

EXPORT SALES: MICROWAVE INTERNATIONAL CORP., 36 W. 44TH ST., N.Y.C., N.Y., U.S.A., CABLE: MICROKEN

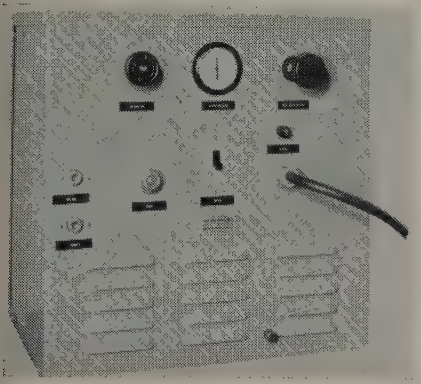


COMPENSATED CAST BENDS • WAVEGUIDE-TO-WAVEGUIDE COUPLINGS • "PANTY" ADAPTERS
E/H AND STRAIGHT ADAPTERS • FOLDED HYBRID TEES • SIDEWALL HYBRID COUPLERS

Circle Reader Service Card 63

(*Continued from page 109*)

two psig pressure. Units can also be furnished for delivery of up to 3000 cu. in./min. of dry air at up to 30 psig.



The unit is engineered for dependable performance within an ambient temperature range of —40 degrees F to plus 140 degrees F, at altitudes between sea level and 7000 feet, and is unaffected by exposure to salt laden air as encountered in coastal U.S. The unit is also drip-proof.

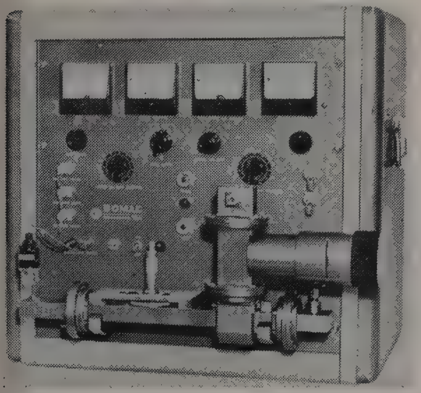
Circle Reader Service Card 131

—*mwj*—

MAGNETRON TEST SET ANNOUNCED BY BOMAC

Test set BLP-002K, recently announced by Bomac Laboratories, Inc., Beverly, Mass., is designed for testing Beacon Magnetrons. Plumbing components include 1) well-matched coaxial line to waveguide transition, 2) pulling device, 3) folded cross guide directional coupler, 4) thermistor mount, 5) frequency meter, and 6) waveguide to coaxial line transition.

The modulator capable of producing .5 and 1.0 μs pulses having a peak amplitude of 3.0 kv at 2.0 amperes, is provided with an internal trigger source, necessary control and meters, plus test jacks for pulse shape viewing test results through an oscilloscope.



The test set is available for C-Band or X-Band testing.

Circle Reader Service Card 132

—*mwj*—

PULSE GENERATOR CONTAINS RE-CHARGEABLE BATTERY PACK

Charles E. Rutherford, president of Rutherford Electronics Co., Culver City, Cal., announces the introduction of a portable, completely transistorized, high speed pulse generator, the Model B-10. One feature of this new instrument is a self contained, rechargeable, battery pack, which allows independent operation "in-the-field" as well as from standard line voltages.

The unit features a main output which is continuously variable in repetition rate from 20 pulses per second to two million pulses per second, or may be triggered from an external source at rates to two megacycles; delay (with respect to the synchronizing pulse output) continuously variable from 0 to 10,000 microseconds; pulse widths continuously variable from 0.05 to 10,000 microseconds; an amplitude of 18 volts into 50 ohms; polarity, either positive or negative, rise and fall times of 0.02 microseconds or less; overshoot and undershoot of five per cent or less, pulse drop of 10 per cent or less at 10,000 microseconds pulse width; a maximum duty factor of 60 per cent at all repetition rates; and automatic overload protection.

Circle Reader Service Card 133

—*mwj*—

WIDE-RANGE FREQUENCY METER-DISCRIMINATOR DEVELOPED

A wide-range pulse-count electronic frequency meter (Type 1142-A), direct-reading over a range of three cps to 1.65 Mc, has been developed by General Radio Co., West Concord, Mass.

By means of a calibrated scale-expansion technique, a direct-reading accuracy of 0.1 per cent is achieved.

In addition to its use in direct frequency measurement, the instrument can be used to make highly precise frequency-drift measurements on oscillators and other generators. By measurement of the heterodyne beat between the oscillator and a suitable frequency standard, an accuracy of one part in 10^9 can be obtained.

(*Continued on page 112*)

MAX-
IMUM
MINIATURIZATION

**ACF ELECTRONICS
C-BAND MICROWAVE
COMPONENTS**

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.

CW LOCAL OSCILLATOR
MODEL NO. 302

Frequency Range: 5400 to 5900 MC
Tuning Range: 500 MC
Power Output: 3 MW (minimum)
Stability: ± 3 MC over all military environmental conditions

Standard designs modified to meet specific requirements. Complete manufacturing and engineering facilities supported by expert field service.

There's an ACF Electronics microwave component to meet requirements in L, S, C or X-Band Frequencies.

ACF RADAR BEACONS are in a majority of orbited satellites and major missile programs.

For information or prices write or call:

ACF
ELECTRONICS
DIVISION OF ACF INDUSTRIES
Paramus Plant, Paramus, N. J.
Telephone: COlfax 1-4100

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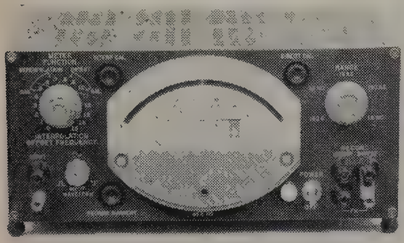
New Products

(*Continued from page 111*)



A DC output for operating a recorder is provided; this is particularly useful in frequency-drift measurements. With the aid of a wave analyzer, incidental frequency modulation can be measured down to one part in 10^6 directly; by indirect methods, down to one in 10^9.

Circle Reader Service Card 134

— *mwj* —

MOTOR-GENERATOR FEATURES LARGE FLYWHEEL

Protecting the continuity of Micro-Wave communications by means of "No-Break Power" a specially designed Motor-Generator, with large flywheel arrangement has been introduced by Kato Engineering Co., Mankato, Minn. In case of failure of normal electric power, the momentum of the large flywheel is designed to keep fluctuation to a minimum until the standby power plant is cut into the line.

This motor generator set features a brushless type generator with direct connected separate exciter, is rated at five kw, 6.25 kva, .8 factor, 120 volts AC, one phase, 50 cps. A Kato mag. amp regulator provides 1½ per cent of rated voltage under one fourth load to full load conditions. Rectifier assembly is mounted on end of shaft for easy replacement of rectifiers.

Circle Reader Service Card 135

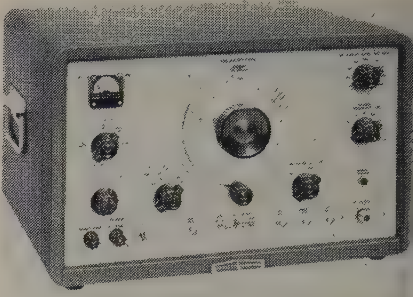
— *mwj* —

MICROWAVE SWEEP OSCILLATORS PROVIDE LEVELED OUTPUT

A series of four microwave sweep oscillators, each providing a leveled power output over its entire swept frequency range, is now available from Hewlett-Packard Co., Palo Alto, Cal.

The versatile sweep oscillators include Model 682C, covering frequencies from 1.0 to 2.0 Gc (kMc); Model 683C, 2.0 to 4.0 Gc, Model 684C, 4.0 to 8.1 Gc and Model 686C, 8.2 to 12.4 Gc. All models provide either a CW or swept rf output throughout their individual bands. Each oscillator has a wide range of sweep speeds so that measurements such as reflection, attenuation and gain can be displayed on an oscilloscope or recorded on X-Y or strip chart recorders.

The instruments employ new backwar wave oscillator tubes whose frequency i shifted by varying an applied potential



This eliminates mechanical stops and tuning plungers. Sweep range is continuousl adjustable and independently variable sweep rate is selected separately, so both rate and range can be changed without interrupting operation.

Circle Reader Service Card 136

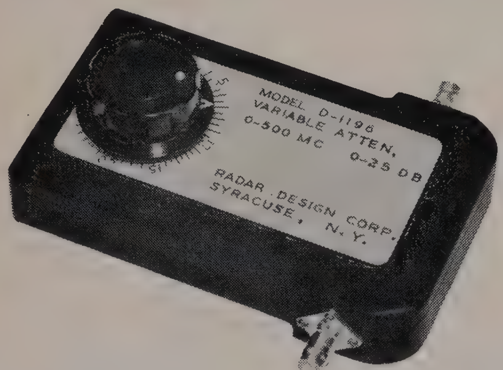
— *mwj* —

Y-CIRCULATOR SWITCH DESIGNED FOR OPERATION IN S-BAND

Rantec Corp., Calabasas, Cal., announces a new Y-Circulator non-reciprocal SPDT Switch, designed for operation at S-band.

(*Continued on page 114*)

EXCLUSIVE - THROUGH RESEARCH



CONTINUOUSLY VARIABLE ATTENUATOR *FLAT* 0-500 MC

RDC* research has produced the only *precision line* of
LT SLOTTED SECTIONS AND TERMINATIONS
TNC SLOTTED SECTIONS AND TERMINATIONS

Perpetual research and development makes available to you over
1,000 SPECIAL COAXIAL DESIGNS

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M S FLANGES

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THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVE-GUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

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DESCRIBING AND ILLUSTRATING ALL THE STOCK FLANGES

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COMPACT, RELIABLE, RUGGED

EG&G CERAMIC-METAL

HYDROGEN THYRATRONS — HYDROGEN DIODES — TRIGGERED SPARK GAPS

These miniaturized hydrogen thyratrons were developed for compact modulator design for missile, airborne, and ground-based applications where size and weight are major considerations. Ruggedly built, they will withstand severe shock, vibration and high temperatures. Write for Data Sheet #040.

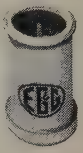
THYRATRON RATING CHART

MODEL	e_{py} v.	i_b a	I_b mAdc	I_p Aac	E_f Vac ±7.5%	I_f Aac—max. E_f=6.3v	E_{res} Vac ±7.5%	I_{res} Aac—max. E_{res}=6.3v	P_b	Cathode & Reservoir Warm-Up Time	Dimensions Max. Height- inches	Dimensions Max. Dia.- inches	Wt. lbs.
7621/HY-2	8,000	100	0.1	2.0	6.3	3.5	*	*	2.7×10^9	0.5 min.	2½"	1⅕"	0.13
7620/HY-1	20,000	500	0.5	8.0	6.3	7.5	6.3	4	10×10^9	5 min.	4⅝"	2 5/16"	0.82
7322/1802	25,000	1,500	1.5	47.5	6.3	16	6.3	6	20×10^9	10 min.	5¾"	3⅜"	2.07

*Hydrogen reservoir connected internally across heater-cathode.
Ambient Temperature Limits —65°C to +125°C, 400°C envelope maximum.

THYRATRONS

7621/HY-2
Functionally replaces 1258, 3C45 and most 4C35 glass tubes



7620/HY-1
Functionally replaces 4C35, 5C22 and most 5949 glass tubes

7322/1802
Functionally replaces 5949, 5948 and most 1257 glass tubes

DIODES

HR-2

HR-1

HR-3

High power, high voltage, hydrogen filled diodes designed for use as grid controlled rectifiers, hold-off diodes, inverse clippers and backswing clippers. In spite of their small size and light weight, they are of rugged construction and will withstand severe shock, vibration and high temperatures. Write for Data Sheet #050.

DIODE RATING CHART

	Clipper Diode Ratings				Rectifier Ratings			Heater				Cathode & Reservoir Warm-up Time	Dimensions		Wt.
Type	e_{px} kv	i_b a	I_b Adc	I_p Aac	e_{px} kv	i_b a	I_b Adc	E_f Vac	I_f Iac max.	E_{res} Vac	I_{res} Iac max.	minutes	Max. Height- inches	Max. Dia.- inches	lbs.
HR-2	8.0	9.0	.100	2.0	8.0	1.5	0.25	6.3	3.2	*	*	0.5	2½	1⅕	0.13
HR-1	25.0	250	.125	4.0	20.0	9.0	1.5	5.0	9.5	5.0	3.5	5	4⅝	2 5/16	0.95
HR-3	25.0	500	.500	16.0	25.0	30.0	5.0	6.3	13.0	6.3	4.0	10	5¾	3⅜	2.07

*Hydrogen reservoir connected internally across cathode-heater.
Ambient Temperature Limits —65°C to +125°C ambient, 400°C envelope maximum.

TRIGGERED SPARK GAPS

These compact spark gaps are designed to replace hydrogen thyratrons in electronic crowbar applications. They have a low trigger energy requirement and a fast follow-through time after application of trigger pulse. Hermetically sealed, they are not affected by atmospheric conditions. Ruggedly built to withstand severe shock, vibration and high temperatures. No filament power required. Complete specifications available on request. Write for Data Sheet #080.

CERAMIC-METAL MODEL GP-12
Voltage holdoff — 25kv.
Peak current — in excess of 10,000 amperes
Trigger voltage — 7 kv. min.
Electrode to electrode cut-off voltage — 6 kv. min.
Delay time — 0.5 microseconds.
Size: 3½" dia. x 2½". Wt. .73 lb.

GLASS-METAL MODEL GP-11
Voltage holdoff — 3.5 kv.
Peak current — in excess of 1100 amperes.
Trigger voltage — 7.5 kv. min.
Electrode to electrode cut-off voltage — 1.8 kv. min.
Delay time — 0.35 microseconds.
Size: 0.6" dia. x 0.55". Wt. .016 lb.

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WESTERN OPERATIONS: P.O. Box 1912, Las Vegas, Nev. — Santa Barbara Airport, P.O. Box 98, Goleta, Calif.

PRODUCTS — milli-mike® Oscilloscopes • Hydrogen Thyratrons • Hydrogen Diodes • Triggered Spark Gaps • Xenon Flash Tubes • Laser Stimulators • Dosimeters Flash Machines & Circuits • Oceanographic Equipment • Transformers • CAPABILITIES — Project Management • Systems Engineering • Research & Development

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E.M.I.
Q-BAND REFLEX
KLYSTRONS

Five high voltage, integral cavity types, with improved plate tuner for good frequency stability and freedom from microphony.

Type No.	Approx. f range KMc/s	Min. Power (mW)	I_A (mA) (at V_A=2KV)
R9521	35—40	15	12
R5146	34.2—35.6	30	10
R9546	32—38	15	12
R9518	28—32	15	12
R9547	24—28	15	12

Average electronic tuning range of above, 60 Mc/s; WG22 waveguide termination.

...AND A NEW K-BAND KLYSTRON:

with similar external dimensions and tuner to R9546:

R9602 22—26 15

Average electronic tuning range, 40 Mc/s; WG20 waveguide termination.

The extensive range of EMI special tubes includes: plug-in klystrons & cavities, photomultipliers, camera & C.R. tubes.

EMI
E.M.I.
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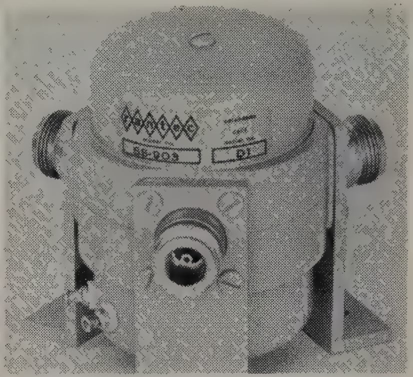
New Products

(Continued from page 112)

The switch is miniaturized, temperature stable, and capable of handling average powers in excess of 100 watts.



The unit provides greater than 20 db of isolation and less than 0.5 db insertion loss over bandwidths greater than 20 per cent (2.7 — 3.3 kMc). It is not sensitive to magnetic switching field values and, therefore, cannot be overdriven. Square wave modulation at a 100 cps rate with rise times of 2.5 milliseconds are possible using a Rantec Model DS-101 Driver.

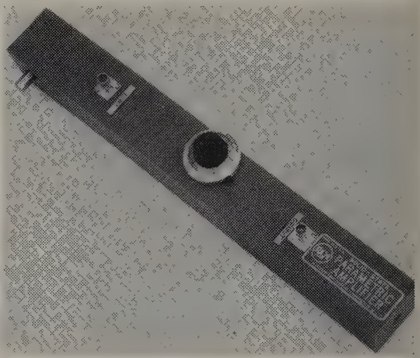
The device can also be used as an electronic attenuator. In this application, hysteresis error is less than ± one db and the difference in attenuation-coil current characteristics varies less than ± two db over the frequency range.

Circle Reader Service Card 137

— *m w j* —

RCA INTRODUCES NEW PARAMETRIC AMPLIFIER FAMILY

A new family of parametric amplifiers, making use of a set of variable-capacitance diodes distributively coupled to a helix, is announced by RCA's Electron Tube Division, Harrison, N. J.



Prototype SS-1000 parametric amplifier delivers one milliwatt of power with 15 db minimum gain and 7.5 db maximum

(Continued on page 116)

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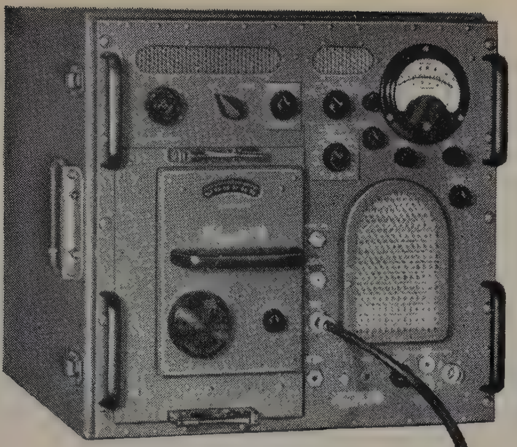


EMPIRE'S Model NF-112

NOISE and FIELD INTENSITY METER 1-10 KMC

One Meter One Antenna

The Empire Devices Model NF-112 is a compact, self-contained noise and field intensity meter...with built-in power supply. Using a single log periodic pick-up antenna...and an impulse generator...it enables you to measure, quickly and reliably, field intensity and RF interference over the entire frequency range from 1-10 KMC.

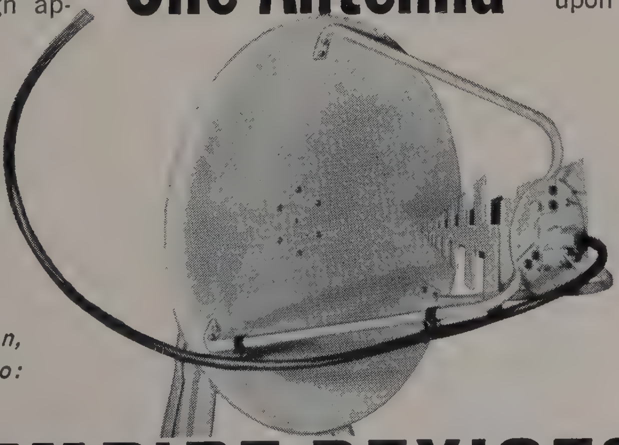
The design, reliability, accuracy, construction and calibration techniques employed in the NF-112 have been successfully proven through many years of field and laboratory use in the low frequency companion instruments, NF-105 and NF-205.

Compactness has been achieved by housing the basic components (common to all frequency ranges) in a single unit, and the necessary RF circuits in four speedily interchangeable, plug-in tuning units... avoiding costly repetition of circuitry and components. This design approach, together with the use of an impulse generator as calibrator, has greatly reduced the instrument's size, weight, complexity and ...best of all...**lowered the cost considerably.**

Model NF-112 measures only 19½" x 18½" x 21½" and, including a tuning unit, weighs 130 lbs. Complete shielding and filtering, plus well-tracked tuned circuits achieve excellent spurious response rejection. A wide band-narrow band switch permits optimum sensitivity for broad band (pulsed signals) and narrow band (CW) reception (AFC, of course). Average and peak reading VTVM (slideback, too).

For measurements in accordance with Specifications MIL-I-6181 C&D, MIL-I-11748-B, MIL-I-26600 and MIL-STD-449.

Plan to attend our next seminar on interference instrumentation, details upon request.



For further technical information, send for Catalog 604 to:

ed **EMPIRE DEVICES, Inc.**
AMSTERDAM, NEW YORK • VICTOR 2-8400

MANUFACTURERS OF: FIELD INTENSITY METERS • POWER DENSITY METERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

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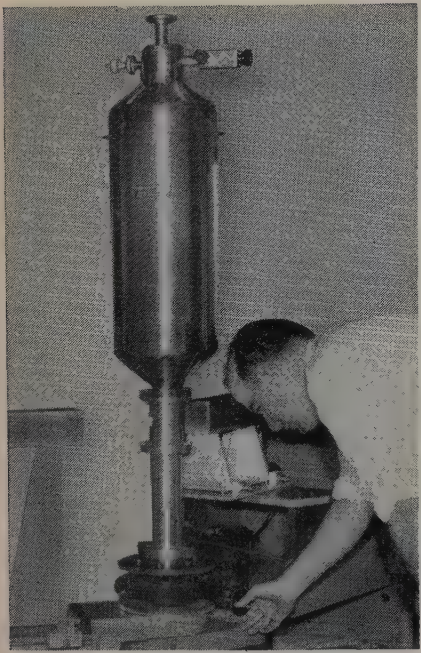
Researching at Liquid Helium Temperatures?



New Dewar Keeps Helium *Over 280 Hours* Without Refilling

This stainless steel dewar was designed for neutron diffraction studies at low temperatures for the U. S. Naval Research Laboratory. The application required that the sample under study be held at liquid helium temperatures for many days. In initial performance tests 4½ liters of liquid helium were used. Data resulting from the tests showed that over 100cc of helium still remained in the Hofman dewar after 280 hours.

SEND FOR NEW CATALOG

Also: Containers for Liquid Oxygen, Nitrogen, Hydrogen and Helium. Accessory Low Temperature Equipment.

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Representatives in principal industrial and military centers.

Circle Reader Service Card 71

(*Continued from page 114*)

noise factor from 2200 - 2300 Mc. Variant SS-1000V1 parametric amplifier delivers one milliwatt of power with 17 db minimum gain and 6 db maximum noise factor from 2190 - 2210 Mc. Both amplifiers have excellent stability, do not require the use of a circulator, and are contained in miniature packages without tuning stubs.

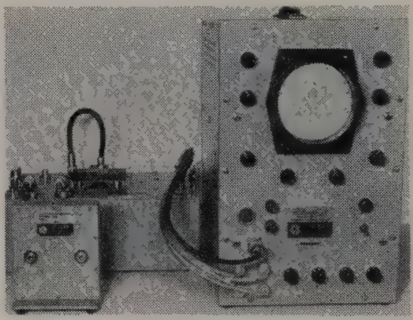
The frequency of the pump source required is only 30 per cent above the signal frequency, and the pump power is 300 - 400 milliwatts. The diodes used in these amplifiers were developed by the RCA Semiconductor and Materials Division.

Variants of this type of amplifier can be supplied in the frequency range of 1750 - 3000 Mc with bandwidths up to 100 Mc.

Circle Reader Service Card 138

—mwj—

AUTOMATIC IMPEDANCE PLOTTER EXPANDS FREQUENCY COVERAGE



Higher and lower frequency ranges than were covered by earlier models are provided in the new AMCI Type 14 Automatic Impedance Plotter from Alford Manufacturing Co., Boston, Mass.

At the low end, an additional range of 0.1 to 2.5 Mc facilitates measurement of crystal-transducer impedances as well as other measurements in sonic and ultrasonic investigations. At the high end, an additional range of 1100 to 1700 Mc increases the overall utility of the equipment. With two intermediate ranges of 2.5 to 250 and 180 to 1100 Mc, this equipment gives complete frequency coverage from 0.1 to 1700 Mc.

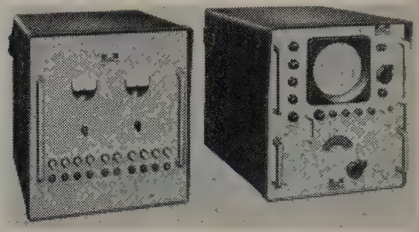
Used in conjunction with a suitable external oscillator, the Type 14 Automatic Impedance Plotter provides continuous impedance information, displayed as a trace on the Smith-chart-calibrated CRT of the Presentation Unit. If a permanent record is required, a separate X-Y recorder can be added to the system without affecting the indication on the CRT.

Circle Reader Service Card 139

—mwj—

POLARAD DEVELOPS EHF SPECTRUM ANALYZER

Polarad Electronics Corp., Long Island City, N. Y., manufacturer of microwave spectral analysis equipment, has developed a high frequency Spectrum Analyzer that displays spectral information between 50,000 and 100,000 Mc.



The Model DA-70 Spectrum Analyzer covers this frequency range in 3 bands: 50 to 62 kMc in Band C, 60 to 80 kMc in Band B, and 75 to 100 kMc in Band A, all contained in one tuning head. The wide band display of up to 1000 Mc can be used to observe a pulsed signal as narrow as 0.01 microseconds.

Applications include: measuring the spectral characteristics of pulse modulated signals, simplifying field intensity measurements, developing countermeasures equipment, comparing two signals having a small frequency difference, testing transmitters and generators for "holes" throughout their tuning range, and in general determining pulse widths and pulse shapes by spectrum analysis techniques.

Circle Reader Service Card 140

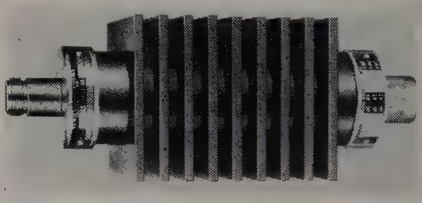
—mwj—

POWER PAD FEATURES BILATERAL POWER INPUT

Weinschel Engineering, Kensington, Md., has introduced a new fixed coaxial attenuator, model 693, which handles an input power of 20 watts CW and 10 KW peak. Cooling fins and black anodized aluminum body dissipate heat efficiently and preserve stable characteristics under full power.

As a result of extensive engineering, the model 693 is matched at both terminals and the full rated power can be applied to either terminal.

To minimize wear, both connectors are made of stainless steel instead of the commonly used plated brass.



Insertion loss calibrations at DC, 400, 750 and 1000 Mc are marked permanently on the attached calibration plate and a Certificate of Calibration is supplied at no extra charge.

Circle Reader Service Card 141

—mwj—

(*Continued on page 118*)

SPERRY *Microline*®

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SMALLEST; LIGHTEST FOR THEIR POWER

Sperry Microline Klystron Power Packages meet practically any laboratory requirement. They have excellent regulation, low ripple, stable operation and versatility of design, with ready adaptability to accessary connections.

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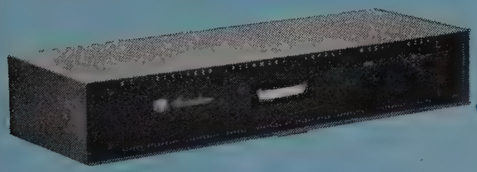
62A1—UNIVERSAL KLYSTRON POWER SUPPLY

Most versatile klystron power unit available today. Widest beam power range (delivers −200 to −4000 volts from 0 to 150ma) in the smallest and lightest package on the market.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62A2—KLYSTRON FILAMENT SUPPLY

Regulated source of filament power for the most critical measurements. With insulation for beam supplies up to 4000 volts, 62A2 can deliver up to 2 amps. with voltages from 2.5 to 10 volts, continuously adjustable. Close regulation; low ripple.

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62A3—KLYSTRON POWER SUPPLY

Ideal for average lab uses—at a moderate price. Supplies most types of klystrons with beam voltages from −200 to −700 volts, using up to 70ma. Weight only 32 lbs.

Available from stock

	62A1	62A3
BEAM	—200—4000 v., continuously adjustable. 0 to 150 ma., 1 v. line regulation, 3 mv. max. ripple.	−200 to −700 v., continuously adjustable. 0 to 70 ma., 1 v. line regulation, 5 mv. max. ripple.
REFLECTOR	0 to −1000 v., .01% regulation, 3 mv. max. ripple.	0 to −1000 v., 0.1% regulation, 5 mv. max. ripple.
FILAMENT	6.3 v., 4 amps., with provision for external filament supply.	6.3 v., 0 to 2 amps.
MODULATION	0 to 250 v., peak to peak, all waveforms.	0 to 150 v., peak to peak, all waveforms.

	62A2
VOLTAGE	2.5 to 10 v. d.c., continously adjustable
CURRENT	2 amps. max.
RIPPLE	5 mv. max.

● For further details and information as to laboratory applications of these power-packed units, please write us:

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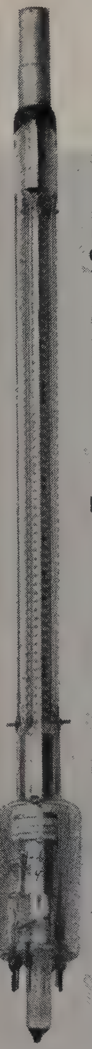

backward wave oscillators–$1 an hour

For an interesting look into the economics of BWOs—or any other specialized electronic tubes—may we suggest that you spread the cost of the last one, that needed replacement over the number of hours it was operated? No matter what hourly rate you come up with, such an evaluation will point up the fact that service life is a much better index of value than purchase price.

Backward wave oscillators made by Stewart Engineering have a built-in life insurance policy in the form of a minimum 500 hour guarantee. Though it is seldom exercised (Stewart backward wave tubes characteristically outlive their guarantees by a wide margin) the guarantee enables you to put high-performance BWOs on your payroll at a known low maximum rate per hour.

Now available:
Type OD 12-18 BWOs
with power output
minimum of 10 MW
in range 12.4-18 kmc.
30-day delivery.
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OD 1-2.

We've prepared an interesting new brochure and specifications on backward wave oscillators, and would like to send you a copy. Details also available on tubes custom-engineered to your specifications. Write today.

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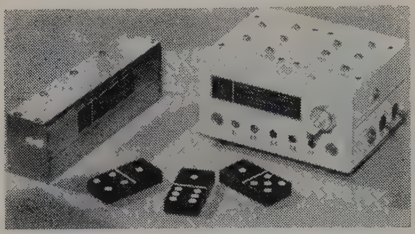
New Products

(*Continued from page 116*)

SOLID-STATE MICROWAVE SOURCES AVAILABLE

Texas Instruments Inc., Dallas, Tex., has announced availability of custom-engineered, solid-state microwave sources and harmonic generators from its recently formed Radar and Microwave Products Department in the company's Apparatus division.

Solid-state sources can be used in any application requiring a fixed-frequency, rf source such as local oscillators, pump sources for parametric amplifiers or as power sources for higher frequency telemetry transmitters. Harmonic generators can be used to frequency multiply existing rf sources to frequencies as high as K-band.



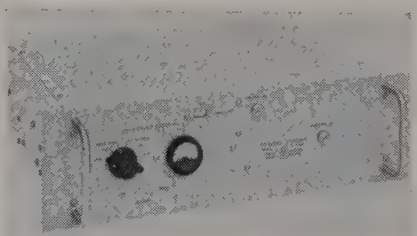
The modular constructed, crystal-controlled sources are available from TI at any frequency from 30 Mc to 10 kMc with power outputs from 4 watts at the lower frequency to 5 mw at 10 kMc. One example, Model S-102, achieves power outputs up to 100 mw with maximum input power of 11 watts at 28 vdc. Model S-102 is available in any specified frequency between 2000 and 2800 Mc, weighs approximately 20 ounces, and measures less than 35 cubic inches.

Circle Reader Service Card 142

—*mwj*—

QUARTZ OSCILLATOR PROVIDES HIGH STABILITY

Improved accuracy in primary frequency and time standard systems is provided by a new, highly stable quartz oscillator developed by Hewlett-Packard Co., Palo Alto, Cal.



The oscillator, Model 103AR, has a long-term stability of five parts in 10^{10} per day. Typical short-term stability, averaged over one-second intervals, is one part in 10^{10} when the instrument is operated in a reasonably constant environment. Compact and completely transistorized, the oscillator serves as a principal element in Hewlett-Packard's new primary frequency and time standard system.

Model 103AR provides two sinusoidal output signals, one Mc and 100 kc, from a low source impedance at a power level well suited for distribution over 50-ohm systems. A separate 100 kc output is available to drive the Hewlett-Packard Model 113BR Frequency Divider and Clock for time comparison measurements and for generating time signals.

Circle Reader Service Card 143

—*mwj*—

TELESCOPE PEDESTAL PRODUCED

A new radio telescope pedestal has been produced by Antlab, Worthington, Ohio.

The Antlab model 3649 pedestal provides accuracy within 0.01° in positioning, under adverse wind conditions, a solid 28-foot diameter radio telescope antenna installed by Massachusetts Institute of Technology at its Lincoln Laboratory, Lexington, Mass.

The pedestal is a two-axis, elevation-over-azimuth mount type, capable of delivering 60,000 ft.-lbs. torque to each axis. It is manually operated by means of two separate sets of azimuth and elevation handcranks. Two operators are to be separately housed in totally enclosed, heated and air-conditioned cabs facing elevation hinge pins.

Azimuth rotation of ±175° is accomplished by stationary bull gear engaging with traveling pinion. Elevation rotation of −5° to +95° is accomplished through two sector gears driven by a pair of idler gears. Three phase induction motors provide slewing speed of 0.1 RPM.

Circle Reader Service Card 144

—*mwj*—

GENERAL CERAMICS INTRODUCES NEW CORES

A line of IF type threaded cores with either screwdriver or hex slot adjustment has been made available by General Ceramics Division of Indiana General Corp., Keasbey, N. J.

The cores are available in various sizes, threads, and types of adjustment and are usually produced in Ferramic Q-1 material for applications at the IF and RF frequencies. They are available in 8-32, 10-32, and 1/4-28 diameters and threads.

Ferramic Q-1 threaded cores are used for permeability adjustment in IF transformers, in conjunction with the IF Type Cup Core. They are also adaptable to all RF coil applications.

Circle Reader Service Card 145

—*mwj*—

MC μ/φ

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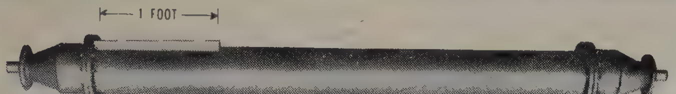

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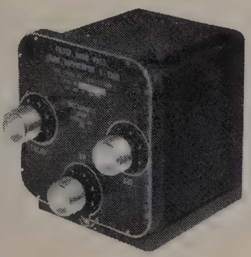

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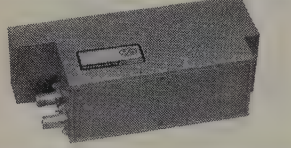

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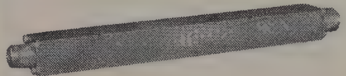

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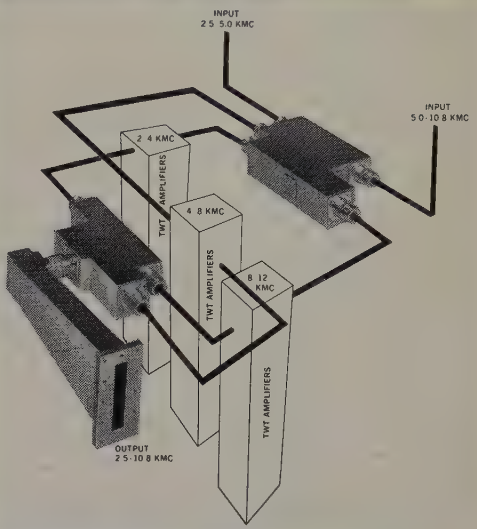

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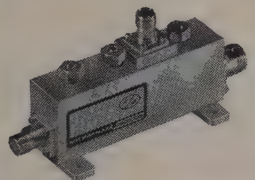

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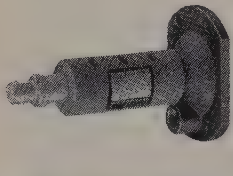

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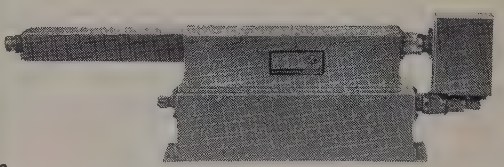

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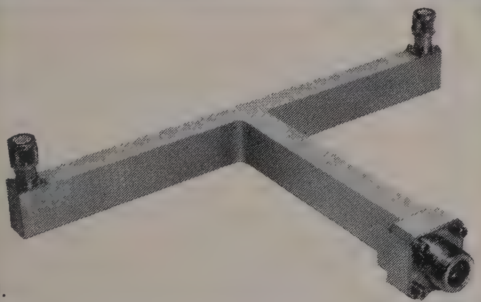

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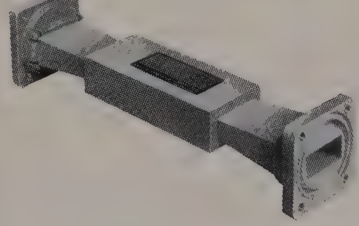

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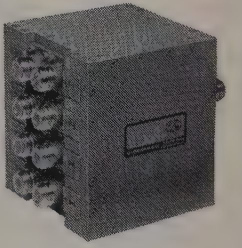

11.

1. High-Power Bandpass Filter for search radar; Model BCC14245. **mwj 5/60.**
2. IFF/TACAN Diplexer F-339/A, fully qualified to MIL-F-25880A; Microphase Model BER 2912C. **mwj 4/60.**
3. All-Solid-State Receiver Head; operates in the L Band; Model SF21718-2; **mwj 1/61.**
4. Calibrated Bandpass Filter for spectra-density measurements; **mwj 10/60.**
5. Broad-Band Multiplexing, using MICROPHASE components; **mwj 7/60.**
6. Preselector/Mixer, for L-Band operation; Model CIP 21619; **mwj 1/61.**
7. Filter Detector, High-Pass, for direct-detection receivers; Model CVF 3810; **mwj 3/61.**
8. Fourth-Harmonic Generator, input signal 625-670 mc; Model CUH-4-150; **mwj 2/61.**
9. Frequency-Selective, Phase- and-Amplitude-Tracked, Power Divider; Model CPDF558; **mwj 8/60.**
10. Medium-High-Power Waveguide Filter for RG-51/U waveguide systems; Model WR310LSX1; **mwj 11/60.**
11. L-Band Octaplexer; satellite applications; Model MP-C218-1; **mwj 3/61.**

For complete specifications on these components, refer to our advertisement in **microwave journal** for the month indicated in the caption, or write us for a reprint.

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BOOK REVIEWS

FREQUENCY-POWER FORMULAS by Paul Penfield, Jr.; The Technology Press of M.I.T. and John Wiley & Sons, Inc., 1960 (jointly published); 166 pp., 2 pp. index, viii pp. ($4.00).

The purpose of this book is the derivation and analysis of relations of the Manley-Rowe type in a form that will permit their use over a wide field of application. Its level is described by a foreword by J. A. Stratton stating that the purpose of the Technology Press Research Monographs, of which this is one, is the "publication of research studies larger in scope than a journal article, but less ambitious than a finished book," and to "make accessible timely and important research studies."

The author discusses four types of relations. Type I, according to his classification, are the Manley-Rowe relations themselves that describe the real power flow in reactive systems. Type II limit the reactive power flow in resistive systems. Type III relations are inequalities of the Page-Pantell sort that limit real power flow in resistive systems. Type IV are similar inequalities that concern reactive power flow in reactive systems. These various relations are established on sufficiently general physical grounds to allow their application to a broad spectrum of devices from rotating machinery to the irrotational electron beam.

There has recently developed recognition of the importance of relations of this type to the analysis of various devices such as the parametric amplifier. These devices involve complex interactions, sometimes involving many frequencies and waves of different character. The complete analysis of such a system can be a very tedious business indeed. The power of these relations is that they allow certain conclusions to be drawn almost by inspection and in advance of any specific analysis. Thus they provide an initial screening of possible devices.

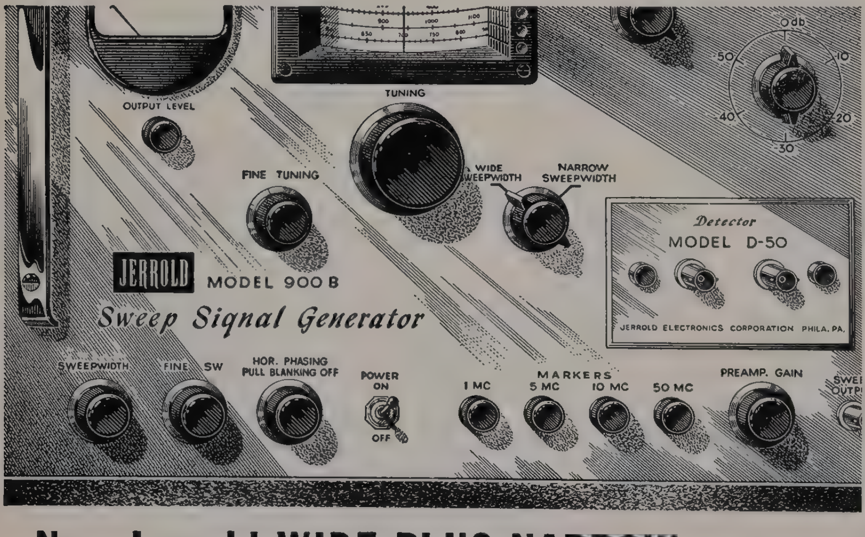
They are also of vital importance in setting boundaries to what is physically realizable. They provide limiting conditions against which a given device can be evaluated, and conclusions reached as to th possible extent of improvement.

This book is a penetrating study of these conservation laws. It establishes them as consequences of the existence of an energy state function in the reactive cases, and of a dissipation function in the resistive cases. These functions are characterized solely by the existing state of the system and time, and not by the past history of the system. From the assertion of the existence of such a function, the conservation laws are shown to follow. They are, therefore, the result of very deep properties of the system.

The book is theoretical in subject, but is written from the engineering point of view—i.e. with close attention to the physical and practical significance of the results. While the book will appeal mainly to the specialist and to those who wish to make specific application of the specialist's viewpoint, it is a very worthwhile contribution to the field.

Reviewed By
M. C. Pease
Associate Editor
the microwave journal

—*mwj*—



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PLASMA ACCELERATION *(The Fourth Lockheed Symposium on Magnetohydrodynamics); edited by Sidney W. Kash; Stanford University Press, 1960; 117 pp. vii pp. ($4.50).*

Plasma acceleration has become a favorite indoor sport. It may be important for injection into thermonuclear devices, and may be even more so for propulsion in space. Only by ionizing material and accelerating it can the desired specific impulse be achieved. Specific impulse is basically nothing more than momentum per unit ejected mass, or the directed velocity of the material. The low binding energy of chemical fuels leads to high fuel-to-payload-ratios, and virtually precludes their use for extended space emissions. It is significant that most of the nine papers at the symposium documented by this book are concerned with the space propulsion aspects of plasma acceleration. The necessary primary energy source—solar radiation or nuclear fuel—for such applications was not a symposium topic.

In spite of the importance of the topic, this fourth Lockheed symposium on magnetohydrodynamics does not seem to be up to the high standards of the previous ones. Some of the papers are good; some are uninspired. Longmire gives a fairly good over-all summary of the problem for interplanetary applications, in pointing out the requirement on exhaust velocity in terms of preserving reasonable initial/final mass ratios. He concludes, among other things, that an exhaust velocity of 3 x 10^6cm/sec, leading to a mass ratio of 2.5, is not too bad. Even this number puts severe restrictions upon the weight of the prime energy source. The only experimental papers are by Marshall and by Starr and Naff; both work by pulsed j x **B** forces, and both report close to 10^7cm/sec, with reasonable conversion efficiency. Marshall accelerates ionized hydrogen in a coaxial tube; the others use an exploding wire and accelerate the metal plasma in a T-tube or coaxial tube. Of the two schemes, Marshall's looks the better.

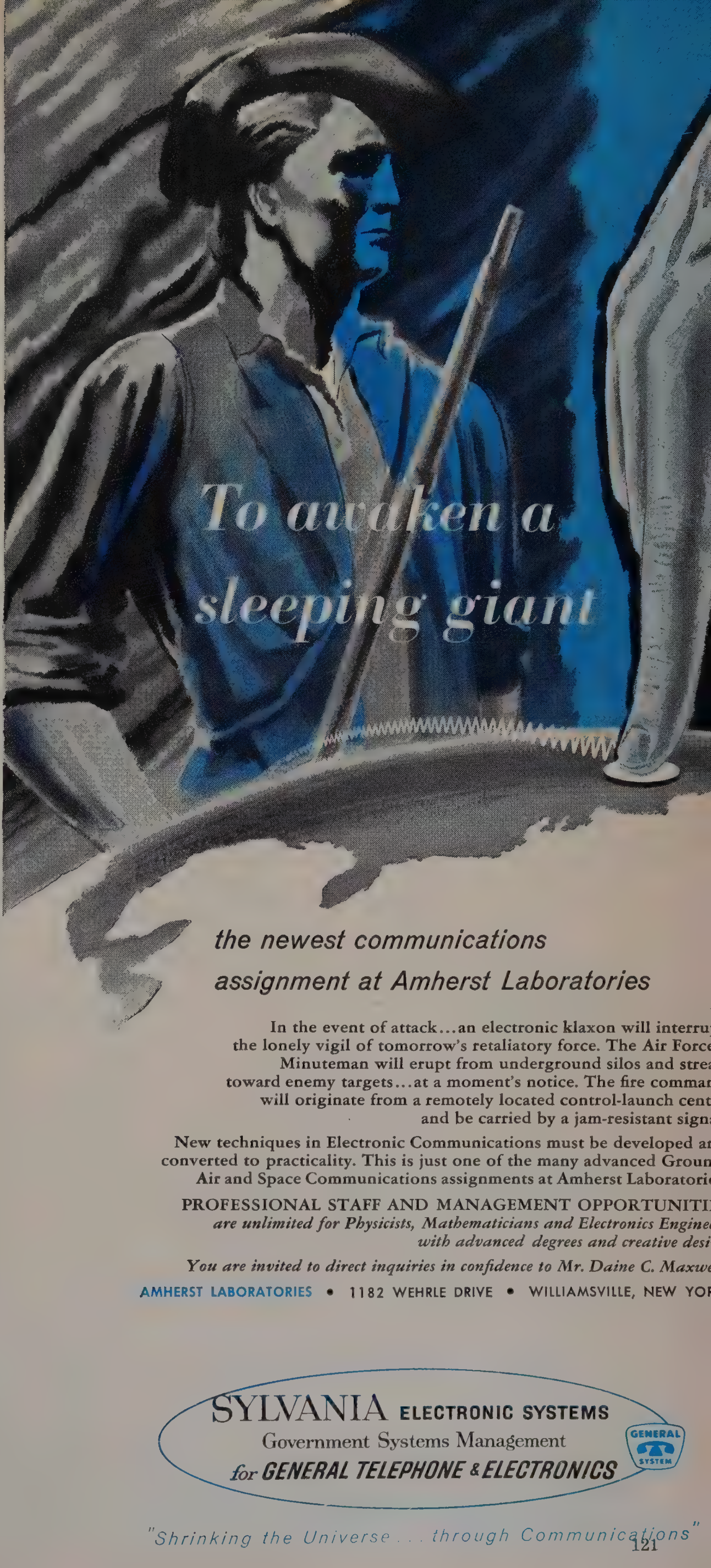
The rest of the papers are theoretical studies, mostly of j x **B** acceleration configurations. Podolsky and Gorman analyze a continuous flow system in a radial sector configuration. Their treatment of transverse and Hall currents is naive and does not apply to a fully ionized gas in the way they imagine. Meyers's analysis of MHD propulsion by a traveling sinusoidal field is interesting. Kash considers efficiency of MHD and electrostatic systems. His treatment of MHD systems by equivalent circuit theory is fairly general and points out the necessity of minimizing the ratio (fixed inductance/plasma inductance) for best efficiency. Kash's electrostatic analysis deals principally with radiation loss from the cathode, without correction for radiation trapping.

The high energy electrostatic gun assembly, by Fox, is an authoritarian analysis of the "omega-field" configuration. It looks something like a railroad yard, with the rails charged alternately positive (the ion source) and negative (accelerating electrode). The field lines, turned upside down, look like the letter ω. Many field plots are shown, with and without space charge, and with and without auxiliary and neutralizing hot-filament electrodes. Fox wonders if sputtering can be controlled by flowing a liquid film over the electrodes.

Taken all together, the book seems less than definitive. Kash has apparently made an effort to have the various authors cross-relate their findings; experience shows that is a difficult task. Too many of the papers are pedestrian, and too many of the analyses are incomplete.

Reviewed by
Prof. David J. Rose
Dept. of Nuclear Engineering
Massachusetts Institute of Technology

—mwj—



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5 KW capacity "diesel" Micro Power units will be available to fulfill growing demand for a thoroughly dependable power supply unit of smaller capacity.

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1953
Intensified design and testing program initiated.

1954
First shipments of 3 KW gas, gasoline Micro Power.

1955
First shipments of 5 KW gas, gasoline Micro Power.

1956
First shipments of 10 KW gas, gasoline Micro Power.

1957
First diesel Micro Power Unit.

1958
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1959
First shipments of 10 KW diesel Micro Power. 100 KW unit designed.

1960
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MODEL MSG-2A 2,000 to 4,600 mc
MODEL MSG-34 4,200 to 11,000 mc
MODEL KSS 1,050 to 11,000 mc
MODEL PMX 4,450 to 11,000 mc
MODEL PMK 10,000 to 21,000 mc
MODEL CSG 1,000 to 16,000 mc
MODEL EHF (Generator) 18,000 to 39,700 mc
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☐ Model MSG-1
☐ Model MSG-2A
☐ Model MSG-34
☐ Model KSS
☐ Model PMX
☐ Model CSG
☐ Model PMK
☐ Model EHF (generator)
☐ Model EHF (source)
☐ A copy of "Notes on Microwave Measurements."

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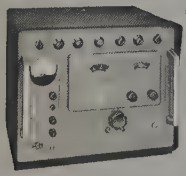
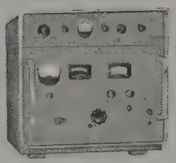
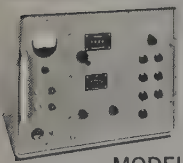


MODEL PMR

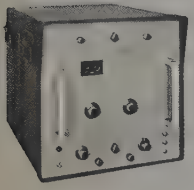


MODEL MSG-2A

MODEL KSS

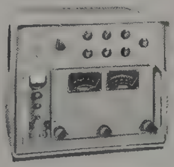


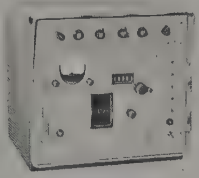
MODEL MSG-34



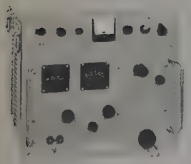
MODEL CSG

MODEL PMX





MODEL PMK



MODEL EHF (Generator)

MODEL EHF (Source)

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MODEL MSG-1	950 to 2,400 mc	Complete modulation capability including square wave modulation
MODEL MSG-2A	2,000 to 4,600 mc	Complete modulation capability including square wave modulation
MODEL MSG-34	4,200 to 11,000 mc	Widest frequency range in a single instrument
MODEL KSS	1,050 to 11,000 mc	Compact high power signal source with plug-in tuning units — internal modulation
MODEL PMX	4,450 to 11,000 mc	Calibrated 1 milliwatt signal generator with complete modulation capability
MODEL CSG	1,000 to 16,000 mc	Higher power sweep generator
MODEL PMK	10,000 to 21,000 mc	Wider modulation capabilities — calibrated 10 milliwatt output
MODEL EHF (generator)	18,000 to 39,700 mc	High frequency signal generator — operates on fundamentals
MODEL EHF (source)	18,000 to 50,000 mc	Widest and highest continuous frequency range — operates on fundamentals

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1961 PGMTT National Symposium

Sheraton Park Hotel, Washington, D.C.

Technical Program

MONDAY, MAY 15, 1961

8:00 A.M. Registration

10:15 A.M. Opening Address —
Symposium Chairman: Robert O. Stone
National Bureau of Standards, Wash., D. C.

10:20 A.M. Keynote Address — Andre G. Clavier
retired, International Telephone and Telegraph Laboratories, Nutley, New Jersey

10:45 A.M. Session I — Millimeter Waves
Chairman: Robert O. Stone
National Bureau of Standards, Wash., D. C.

10:45 A.M. "Quasi-Optical, Surface-Waveguide, and Other Components for the 100 to 300 kMc Region."
F. Sobel and J. C. Wiltse — Electronic Communications, Inc., Timonium, Md.

Analytical and experimental studies were performed to evaluate various components and techniques from 100 to 300 kMc. Phase-corrected Fresnel zone plates were studied in detail; some properties and applications of these plates are presented.

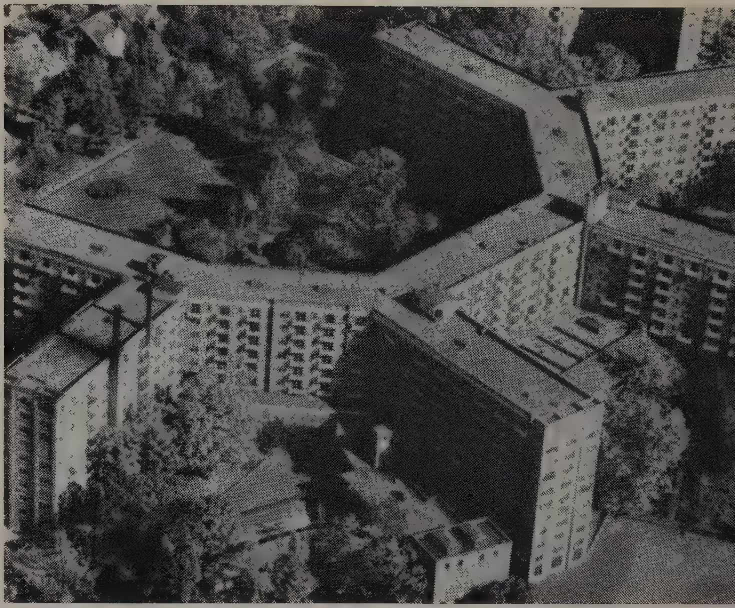
11:10 A.M. "A Millimeter Wave Fabry-Perot Maser"
W. Culshaw and R. C. Mockler
National Bureau of Standards, Boulder, Colorado.

The characteristics and design considerations for the use of a Fabry-Perot resonator as part of a maser are presented. State-selection problems and the minimum number of molecules required for maser oscillation and amplification are discussed.

11:35 A.M. "Broadband Isolators and Variable Attenuators for Millimeter Frequencies"
C. E. Barnes
Bell Telephone Lab., Murray Hill, New Jersey

Faraday rotators with rotation independent of frequency in a band greater than 20% centered at 55 kMc have been developed. Broadband isolators and variable attenuators have been designed using these rotators.

12:00 NOON - LUNCH



Air view of the Sheraton-Park Hotel, Washington, D. C., where the 1961 PGMTT National Symposium will be held.

2:00 P.M. Session II — Parametric Devices
Chairman: W. W. Mumford
Bell Telephone Lab., Whippany, New Jersey

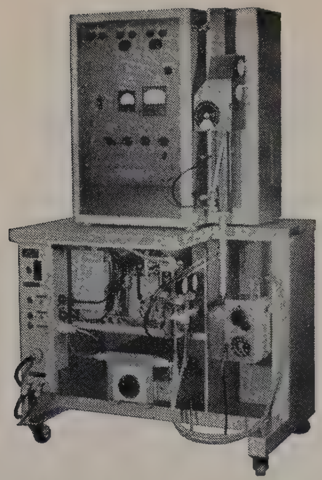
2:00 P.M. "Transmission phase Relations of Four-Frequency Parametric Devices"
D. B. Anderson and J. C. Aukland
North American Aviation, Anaheim, California

The transmission phase properties of parametric amplifiers are discussed. This matter is of extreme importance in angular detection systems, such as monopulse radars and interferometers, which use parallel signal channels. The analysis follows the matrix representation of a nonlinear capacitive reactance, four-frequency device and is comprehensive in its covering of the various types of parametric amplifiers.

"A Traveling-Wave Parametric Amplifier"
T. H. Lee — Lockheed Aircraft Corporation, Sunnyvale, California

This paper presents an analysis of a broadband traveling wave parametric amplifier in which the variable capacitance diodes are connected in series with the signal

(*Continued on page 126*)



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PGMTT PROGRAM

(Continued from page 125)

line rather than in shunt, resulting in a structurally and operationally simpler amplifier.

"An Electronically Tuneable Traveling-Wave Parametric Amplifier"

R. C. Honey — Stanford Research Institute, Menlo Park, California

This paper discusses a TW parametric amplifier incorporating several novel features which enable it to amplify in a narrow band that can be electronically tuned over a very wide frequency range by changing the pump frequency. A theoretical analysis and a graphical design technique is presented. A completed version with selected pill varactors which is capable of being tuned from very low frequencies to 2.25 kMc is also discussed.

3:15 P.M. COFFEE BREAK

"Practical Design and Performance of Nearly Optimum, Wideband, Degenerate Parametric Amplifiers"

M. Gilden and G. L. Matthaei
Stanford Research Institute, Menlo Park, California

The nearly optimum, wideband performance of a single diode, degenerate parametric amplifier is obtained by using a series-resonated diode (rather than shunt) in an almost lumped constant network, and a separate pump resonator which is very lightly coupled to the diode and signal circuits. At 1 kMc, the amplifier offers 15 db midband gain, 1 db double channel noise figure and 20% bandwidth for the two resonator type compared to 8% using one resonator.

"Design Theory of Up-Converters for Use as Electronically Tuneable Filters"

G. Matthaei — Stanford Research Institute, Menlo Park, California

The single diode, upper or lower sideband up-converters discussed, use a wideband filter at the signal port, a moderately wideband filter at the pump port, and a narrow-band filter at the sideband output port, which permit selection of the input signal frequency by varying the pump frequency.

"Passive Phase-Distortionless Parametric Limiters"

I. T. Ho, and A. E. Siegman
Stanford University, California

This paper presents the theoretical analysis and experimental results of a parametric limiter at S-band under CW or pulsed excitation. Theoretical expressions for the limiting threshold, bandwidth and dynamic range in terms of varactor diode characteristics are compared with experimental results.

7:30 P.M. EVENING MEETING

"The Business of Inventing"

Jacob Rabinow — President, Rabinow Engineering Co., Wash., D.C.

TUESDAY, MAY 16, 1961

9:00 A.M. Session III — Ferrites
Chairman: Frank Reggia
Diamond Ordnance Fuze Lab., Washington, D. C.

9:00 A.M. "Field Displacement Devices"
G. J. Wheeler — Sylvania Electric Products, Mountain View, Calif.

The field displacement effect in a ferrite-loaded waveguide has been utilized to obtain an absorption modulator for high-speed switching or amplitude modulation of microwave energy. This ferrite modulator, when used as a microwave switch, is capable of high isolation and low insertion loss with small magnetic control fields.

9:25 A.M. "A Field Displacement Isolator at 57 kMc"
C. E. Fay and E. F. Kankowski
Bell Telephone Lab., Murray Hill, N. J.

This paper describes a field displacement isolator which makes use of oriented barium ferrite with a very high anistropic field to considerably reduce the high field requirements of isolators at millimeter wavelengths. This isolator has an insertion loss of approximately 1 db in the forward direction and an isolation of 60 db in the reverse direction over the 56 to 58 kMc frequency range.

9:50 A.M. "Solid State X-band Power Limiter"
W. F. Krupke, T. S. Hartwick, and M. T. Weiss, Hughes Aircraft, Culver City, California

This paper describes recent ferrite limiter results and reports on a new limiter concept which makes use of a reflection-type diode limiter and a ferrite limiter in tandem. These ferrite-diode combination limiters, which have an operation bandwidth of 700 Mc at X-band, have been successfully operated in the medium power range.

10:15 A.M. COFFEE BREAK

10:30 A.M. Frequency Doubling with Planar Ferrites and Isotropic Ferrites with large Saturation Magnetizations"
I. Bady — USASC Research and Development Lab., Ft. Monmouth, N. J.

Experiments conducted with long thin ferrite slabs in rectangular waveguide show that planar ferrites are more efficient for frequency doubling than isotropic ferrites. This efficiency is increased further by making use of a traveling ring circuit. The fundamental frequencies used for the experiments ranged from 8500 Mc to 9400 Mc.

10:55 A.M. "Octave Bandwidth UHF/L-Band Circulator"
F. Arams, B. Kaplan and B. Peyton
Airborne Instruments Lab., Melville, Long Island, N. Y.

A broadband four-port phase-shift-type circulator for the UHF/L-band has been developed which makes use of an aluminum-substituted yttrium-iron-garnet with a low saturation magnetization. This circulator has an insertion loss of 1 db or less, a minimum isolation of 20 db and an input VSWR of approximately 1.15 over the 665 Mc to 1320 Mc frequency range.

(*Continued on page 129*)

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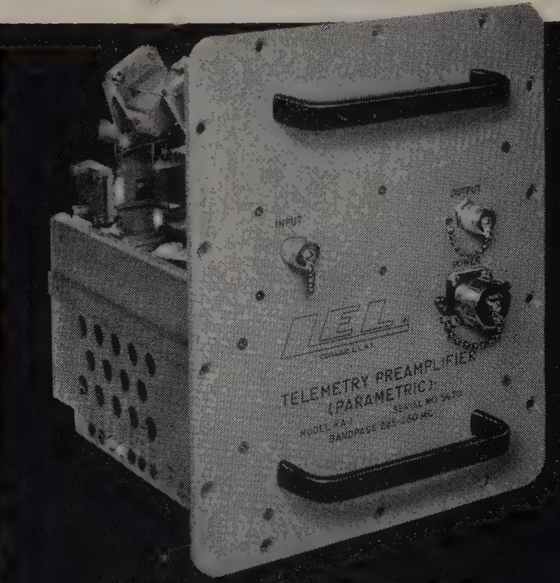

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Steering Committee members plan the 1961 National Symposium. Left to Right are Dr. Helmut Sommer, Diamond Ordnance Fuze Labs., member at large; Robert V. Garver, Diamond Ordnance Fuze Labs., chairman Local Arrangements Committee; Gustave Shapiro, National Bureau of Standards, chairman Technical Program Committee; Robert O. Stone, National Bureau of Standards, Chairman 1961 PGMTT National Symposium; Charles E. Quigley, Naval Research Laboratory, Symposium Secretary; Frank Reggia, Diamond Ordnance Fuze Labs., Symposium Treasurer.

PGMTT PROGRAM

(*Continued from page 127*)

11:20 A.M. "A New Balanced Type Ferrite Switch"
T. Kuroda and A. Cho
Nippon Electric, Tokyo, Japan

This paper describes a reactive microwave switch which makes use of a longitudinally magnetized ferrite rod in a modified rectangular waveguide system. Two of these reactive ferrite devices are then used in conjunction with two hybrid junctions to obtain a balanced type microwave switch which makes use of non-critical control field and is insensitive to changes in temperature.

12:00 NOON - LUNCH

2:00 P.M. Session IV — High Power Microwave Techniques Panel
Chairman: Clarence Jones
Massachusetts Institute of Technology, Cambridge, Mass.

"Spurious Outputs From High Power Microwave Tubes and Their Control"
K. Tomiyasu— General Electric Company, Schenectady, N. Y.

"Windows"
D. B. Churchill — Sperry Gyroscope Co., Great Neck, N. Y.

"High Power Duplexers"
E. Muehe — MIT, Lincoln Laboratories, Lexington, Mass.

Panel Members

C. R. Beitz—Cornell Aeronautical Lab., Buffalo, N.Y.
J. B. Griemsman — Polytechnic Institute of Brooklyn, Brooklyn, N.Y.
L. Gould — Microwave Associates, Burlington, Mass.

2:00 P.M. Session V — Low-Noise Microwave Amplifiers
Chairman: G. Wade
Raytheon Company, Burlington, Mass.

"Traveling Wave Tubes"
D. A. Watkins — Stanford University, Stanford, California

"Parametric Amplifiers"
R. D. Weglein — Hughes Aircraft Co., Malibu, California

"Masers"
H. E. D. Scovil — Bell Telephone Lab., Murray Hill, New Jersey

Panel Members

K. K. N. Chang — RCA Laboratories, Princeton, N.J.
J. W. Meyer— MIT, Cambridge, Mass.
J. Weber — University of Maryland, College Park, Md.

6:00 P.M. COCKTAIL HOUR

7:00 P.M. BANQUET
Speaker: Dr. John R. Pierce
Director of Research, Communications Principles, Bell Telephone Labs., Murray Hill, N. J.

WEDNESDAY, MAY 17, 1961

9:00 A.M. Session VI — Plasma
Chairman: N. Marcuvitz
Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

9:00 A.M. "Microwave Instrumentation for Plasma Research"
E. G. Schwartz and H. H. Grimm
General Electric Co., Syracuse, N. Y.

Instrumentation has been developed to make extensive microwave measurements on shock introduced plasmas, each of which exists for a small number of milliseconds. The equipment operates at two frequencies, one near 8 kMc and the other near 60 kMc. All the components are capable of withstanding 100 kw peak power levels at 8 kMc.

(*Continued on page 130*)

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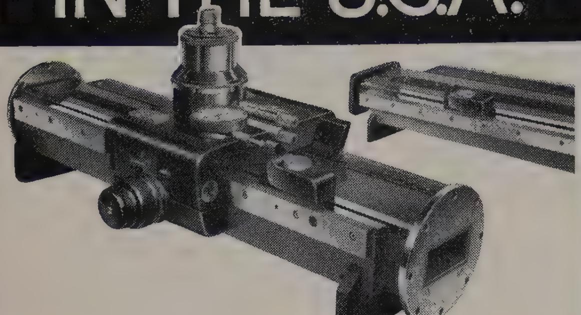

W. H. Sanders (Electronics) Ltd., a leading British supplier of microwave components and test equipment to the European electronics industry, now makes its precision equipment available to the American market. Traditional British craftsmanship coupled with a first class research and development organization, is presently producing a wide line of equipment and components for the bands 2.60-18.00 kMc/s. Soon to be released are equipments and components for the bands 26.5-40 kMc/s. Research and development is also going forward in the millimetric bands.

A recent development is the Universal Standing Wave Detector, illustrated. Capable of impedance measurements at any frequency within the range 2.60-12.40 kMc/s, this instrument is a step towards meeting the demands created by the microwave engineer for a universal standing wave detector in his laboratory.

The assembly comprises a universal probe carriage, which can be attached to any of a series of waveguide sections in both standard and non-standard guide sizes, and will measure to any accuracy of 0.5% of impedance.

Carriage	Waveguide Section	Frequency Range
UPC10/16	WS 16	8.2 - 12.4 kMc/s
UPC10/16	WS 15	7.0 - 10.5 kMc/s
UPC10/16	WS 14	5.85 - 8.2 kMc/s
UPC10/16	WS 13	4.90 - 7.05 kMc/s
UPC10/16	WS 12	3.95 - 5.85 kMc/s
UPC10/16	WS 11	3.30 - 4.90 kMc/s
UPC10/16	WS 10	2.60 - 3.95 kMc/s

Through Hoffman Electron Tube Corp., American representatives to the Sanders Group of Companies, a nation wide network of engineering representatives is available to assist you with your requirements. Send for complete technical data on the Universal Standing Wave Detectors as well as other precision microwave components manufactured by W. H. Sanders (Electronics) Ltd. Many of the instruments are stocked in the U.S.A. for prompt delivery.

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PGMTT PROGRAM

(*Continued from page 129*)

9:25 A.M. "Precision Measurements of Plasma Afterglows"
E. H. Holt, K. C. Stotz, and S. Pike
Rensselaer Polytechnic Institute, Troy, N. Y.

The general problem of plasma study becomes simplified by the removal of any energy input. The plasma "decays" by processes of radiation and various types of particle interactions. The paper describes a scheme to determine two to three orders of magnitude change in the plasma density by detection of very small rapidly changing phase shifts.

9:50 A.M. "Electromagnetic Properties of Weakly Ionized Argon"
F. L. Tevelow and H. D. Curchack
Diamond Ordnance Fuze Lab., Wash., D. C.

Electromagnetic properties of weakly ionized argon are determined by approximating that the gas is a dielectric slab inclosed in a waveguide. The measurements are made in a shock tube at 10 kMc and are time resolved with total test time less than 300 microsecond. Curves of electron density, complex propagation constant and reflection coefficient are given as a function of distance behind a shock front for shock Mach numbers 7 to 9.

10:15 A.M. COFFEE BREAK

10:30 A.M. "The Radiation Field and Q of a Resonant Cylindrical Plasma Column"
W. D. Hershberger — UCLA, Los Angeles, California

A cylindrical plasma column placed across a waveguide or situated in free space in such a fashion that the electric field of an incoming wave is perpendicular to the axis of the column displays a series of resonant responses constituting a reflection and absorption spectrum. The paper discusses the electromagnetic field associated with the assumed electronic motion for the principal member of the spectrum and the factors which determine the width of the resonant response of this member.

10:55 A.M. "A Plasma Guide Microwave Selective Coupler"
W. H. Steier and I. Kaufman
Space Technology Lab., Canoga Park, California

A selective plasma guide coupler is described. The coupling of plasma guide coupler can be continuously varied from less than −40 db to 8.5 db and it is believed that maximum coupling can be increased still further. Pulse power levels of greater than 100 watts at X-band can be handled.

11:30 A.M. LUNCH

1:30 P.M. Session VII — System and Receiver Noise Performance Clinic
Chairman: Herman Haus
Massachusetts Institute of Technology, Cambridge, Mass.

Speakers

"Measurement of System and Receiver Performance"
R. S. Engelbrecht — Bell Telephone Labs., Whippany, N. J.

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The concept of operating noise temperature is employed in order to compare the noise performance of various receiving systems in terms of their environment (sky noise, etc.,), component characteristics (noise figure, effective input noise temperature, gain, bandwidth, etc.), and intended use (one or two channel, radar or radiometry, etc.).

"Some Typical Examples"

Robert Adler — Zenith Radio Corporation, Chicago, Ill.

Parametric amplifiers accept signal and noise inputs on more than one channel. To evaluate their weak-signal performance in a given installation we must know not only about the amplifier itself but also about the antenna system and the type of signal. The last two factors have surprisingly large effects and may swing the balance in favor of one or another type of amplifier. This is illustrated by practical examples.

"Commentary on Methods of Measurements"

M. T. Lebenbaum — Airborne Instruments Lab., Melville, L. I., N. Y.

The general methods of noise figure measurement will be briefly reviewed. The special problems introduced by the peculiarities of negative resistance devices are emphasized, and some precautions suggested. Hot and cold body loads for measurement of very low noise temperature systems are described.

4:30 P.M. ADJOURNMENT

Industry News

(*Continued from page 52*)

R.A.F. ORDERS COSSOR AIRFIELD RADAR

Airfield surveillance radar for the R.A.F. has been ordered from Cossor Radar & Electronics Limited, Essex, England, by the Ministry of Aviation.

The contract covers a substantial number of static Cossor CR.787 installations for use at R.A.F. airfields in this country and abroad. It follows an earlier contract for a smaller number of the same Cossor equipment in mobile form. The mobile version, complete with its power supply unit, can be transported in a single aircraft and brought into operation within a few hours of landing.

Much of the static installation will consist of duplicated S-band transmitter/receivers and radar displays. Similar Cossor equipment is in use at civil airports in many overseas countries. It is also used by the Royal Navy for air traffic control purposes.

The Cossor CR.787 incorporates devices for the elimination of echoes from fixed objects such as mountains and buildings, and also achieves a high degree of discrimination against rain.

— *m w j* —

INDUSTRIALIST PREDICTS GROWTH OF SAN MATEO INDUSTRY

A San Mateo, Cal. industrialist has predicted that the sustained growth experienced in that area since World War II would continue unabated during 1961.

Willard Feldscher, Vice President and General Manager of the Sierra Electronic Corp. Division of Philco Corp., spoke on the occasion of his installation as President of the Peninsula Manufacturers Association:

"There is no reason to believe that the conditions between San Francisco and San Jose which have consistently attracted industry for the past 15 years will prove any less attractive in 1961 and this area should experience substantial and undiminished growth."

Mr. Feldscher made his remarks before an estimated 300 Peninsula businessmen who gathered in the Pacifica Room of the Villa Hotel, San Mateo, to chart a course for business on the Peninsula for 1961.

— *m w j* —

FOUR FIRMS STUDY ADVANCED TRACKING ANTENNA

Selection of four companies to engage in a four month study designed to investigate the feasibility of an advanced space tracking antenna has been announced by the California Institute of Technology Jet Propulsion Laboratory, Pasadena, Cal.

The four companies were selected from 17 which made proposals to JPL on November 7 following a two-day briefing September 29 and 30 at JPL and Goldstone, Cal., site of the Goldstone Tracking Station in the World-Wide Deep Spac Instrumentation Facility (DSIF).

The selected companies are: Westinghouse Electric Corp., East Pittsburgh, Pa. Blaw-Knox Equipment Division, Blaw-Knox Co., Pittsburgh, Pa.; Hughes Aircraft Company Ground Systems, Fullerton Cal.; and North American Aviation Inc. Columbus, Ohio.

Each of the four companies will submi to JPL by late spring, 1961, a desig analysis of a large tracking antenna fron 200 to 250 feet. At present, the three DSI stations at Goldstone, Woomera, Australi and the one being constructed at Krugersdorp, South Africa, employ tracking antennas 85 feet in diameter. If technicall and financially feasible, the advanced antennas would increase the DSIF communications capability 10 to 30 times.

— *m w j* —

LENKURT ACQUIRES JORGENSEN

Wayne H. Jorgensen has joined Lenkur Electric Co., Inc., San Carlos, Cal., as an electrical engineer in the Microwave Products project group, assigned to video amplifier circuit design.

He previously had been with the Minneapolis-Honeywell Co. as an electrical engineer working on design and developmen of sonar transponders. Jorgensen receive his BSEE from the University of Wisconsin.

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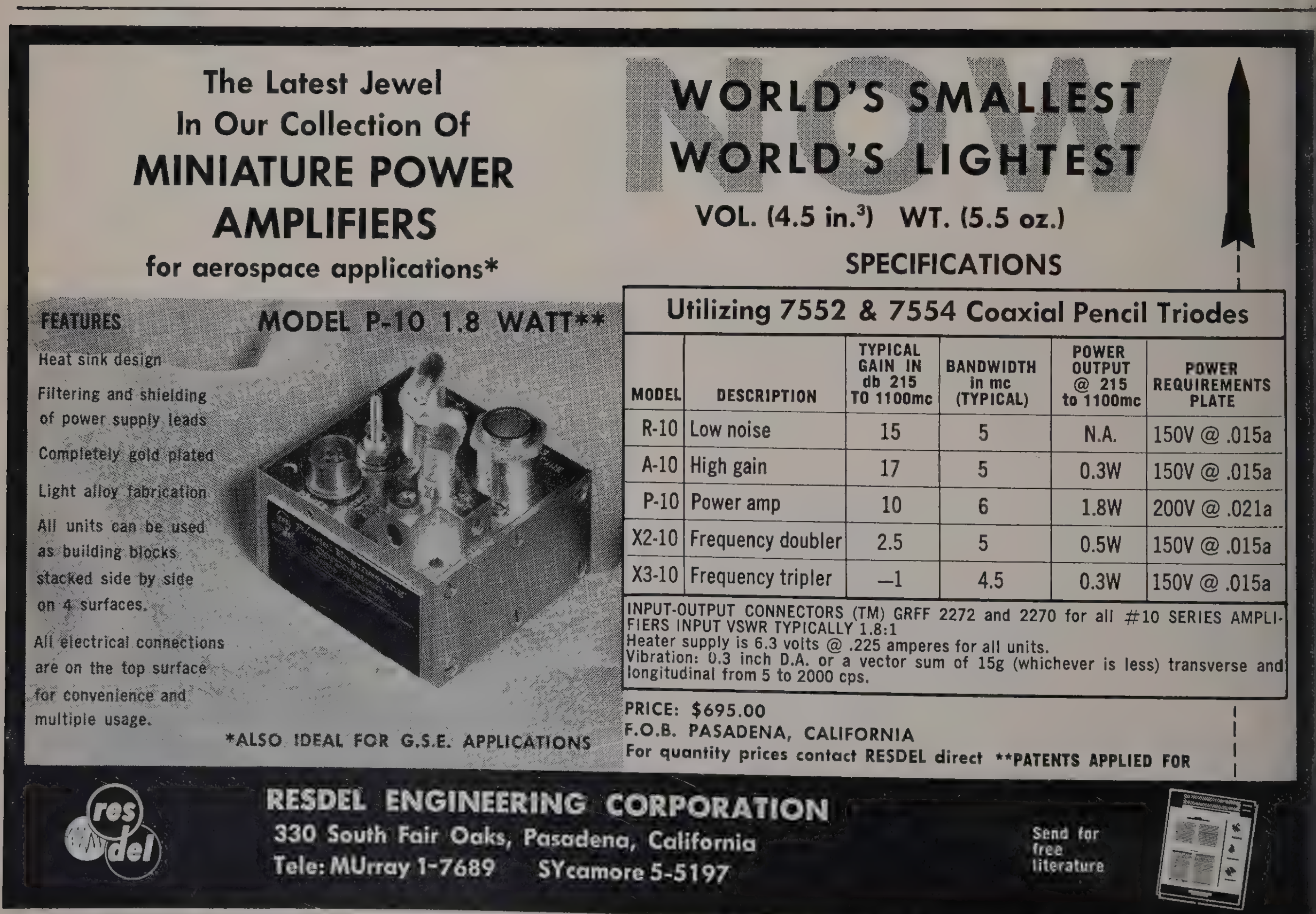

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- Completely gold plated
- Light alloy fabrication
- All units can be used as building blocks stacked side by side on 4 surfaces.
- All electrical connections are on the top surface for convenience and multiple usage.

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NOW WORLD'S SMALLEST WORLD'S LIGHTEST

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SPECIFICATIONS

Utilizing 7552 & 7554 Coaxial Pencil Triodes

MODEL	DESCRIPTION	TYPICAL GAIN IN db 215 TO 1100mc	BANDWIDTH in mc (TYPICAL)	POWER OUTPUT @ 215 to 1100mc	POWER REQUIREMENTS PLATE
R-10	Low noise	15	5	N.A.	150V @ .015a
A-10	High gain	17	5	0.3W	150V @ .015a
P-10	Power amp	10	6	1.8W	200V @ .021a
X2-10	Frequency doubler	2.5	5	0.5W	150V @ .015a
X3-10	Frequency tripler	—1	4.5	0.3W	150V @ .015a

INPUT-OUTPUT CONNECTORS (TM) GRFF 2272 and 2270 for all #10 SERIES AMPLIFIERS INPUT VSWR TYPICALLY 1.8:1
Heater supply is 6.3 volts @ .225 amperes for all units.
Vibration: 0.3 inch D.A. or a vector sum of 15g (whichever is less) transverse and longitudinal from 5 to 2000 cps.

PRICE: $695.00
F.O.B. PASADENA, CALIFORNIA
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ACTUAL SIZE

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HIGH CUTOFF FREQUENCY GALLIUM ARSENIDE VARACTORS

Diffused junction, mesa varactor diodes in a 0.3 mμh package with high f_{CO}, designed for:

PARAMETRIC AMPLIFIERS • MICROWAVE SWITCHES • HARMONIC GENERATORS

SPECIFICATIONS INCLUDE:

Type	f_{CO}	Q
MS262	60 kmc	20
MS263	81	27
MS264	99	33
MS265	120	40
MS266	144	48

Q is measured at $V_R = 2V$ and 3KMC
All units rated 6V minimum breakdown at 10μa

LOW INDUCTANCE PILLBOX PACKAGE

LOW NOISE GERMANIUM TUNNEL DIODES

High frequency, low capacitance, and low inductance tunnel diodes designed for:

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SPECIFICATIONS INCLUDE:

	MS222	MS223	MS224	MS242		
I_p	1.5	1.5	1.5	20	ma	
Noise Constant	1.70	1.50	1.30			max.
C	5	5	5	20	μμf	max.
R_s	2.5	2.5	2.5	1.0	ohms	typical
Cutoff frequency	3.5	3.5	3.5	4.5	KMC	typical
I_p/I_v	8:1	10:1	8:1	10:1		typical

Noise constant is defined as 20 $I_O R$
Low inductance pillbox package (0.3mμh)

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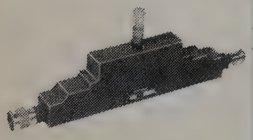
Zero Loss Continuously Variable Coaxial Attenuators

Constant attenuation at any level over broad frequency bands... flat from 4 to 8 kmc and 8 to 12.4 kmc.

PAT. 2,979,678

AE-6
AF-6



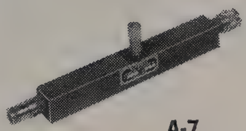
AU-10

UHF, high power attenuator . . . 300 to 5000 mc bands . . . up to 60 db range for 10 watts average power rating.

PAT. 2,979,678

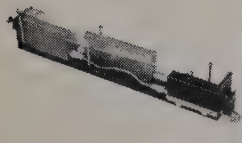
Low cost unit providing up to 60 db of attenuation range in the 1 to 7 kmc band.

PAT. 2,979,678



A-7
A-10

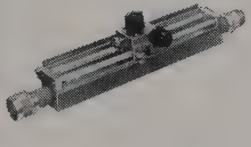
SUB-SYSTEM PACKAGING CAPABILITIES



This special airborne assembly illustrates our capability in designing, developing, packaging and producing microwave subsystems.

OTHER NOVEL MICROWAVE COMPONENTS

For use over the 1 to 8 kmc band . . . provides smooth tuning over entire Smith Chart.



ST-10

IN DEVELOPMENT
Octave Wide Coaxial Magic Tee
D.C. To 4 kmc Flat Variable Attenuator
Low Capacity Octave Wide Crystal Mount

Merrimac
Research and Development, Inc.
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(Continued from page 132)

QUALITY-CONTROL MANAGER APPOINTED AT NARDA

Lester Lipset has been appointed manager of the quality-control department of the Narda Microwave Corp., Mineola, L.I., N.Y., and will be in charge of the eight various stages of inspection and testing operations at Narda.

Previously, Mr. Lipset was Narda's chief test engineer and quality control engineer, in which capacities he was responsible for analyzing the design and development engineering of Narda's new products with respect to quality control considerations. He also had complete responsibility for final production testing of Narda's products, both commercial and military.

Mr. Lipset studied electrical engineering at Adelphi College and New York University. He is a member of the Institute of Radio Engineers.

— *m w j* —

REPORTS HIGHLIGHT CONVENTION

Five state-of-the-art reports by specialists will highlight the technical program of the Fifth National Convention on Military Electronics (MIL-E-CON 1961), according to Harry Davis, Chairman of the Technical Program Committee.

MIL-E-CON 1961 will meet at the Shoreham Hotel, Washington, D. C., on June 26, 27, and 28, 1961. This annual meeting is sponsored by the Professional Group on Military Electronics (PGMIL) of the Institute of Radio Engineers (IRE). Major General Francis L. Ankenbrandt, USAF (Ret.), member of the Technical Staff of Defense Electronic Products, RCA, Camden, New Jersey is Convention President for MIL-E-CON 1961.

The topics and sponsors of the five state-of-the-art sessions are: Low-Noise Amplifiers, Dr. Matthew N. Lebenbaum, Airborne Instruments Laboratory; Computer Technology, Dr. Samuel N. Alexander, National Bureau of Standards; Space Physics, Dr. Robert Jastrow, National Aeronautics and Space Administration (NASA); Plasma Physics, Professor Walter K. Kahn, Polytechnic Institute of Brooklyn; and Radio and Radar Astronomy, Dr. John P. Hagen, NASA.

The United States Air Force Research and Development Command (ARDC) will sponsor five classified sessions at MIL-E-CON 1961. Tentative arrangements have been made for the following topics to be discussed: Anti-Submarine Warfare, Office of Naval Research, Aerospace Physics, Aerospace Corporation; Command and Control, Mitre Corporation and Command and Control Development Division, ARDC; Satellite Communications, U.S. Army Research and Development Laboratories and Defense Communications Agency; Project DEFENDER, Advanced Research Projects Agency.

The 1961 Conference Proceedings will be distributed free to all registrants at the Convention and will contain the unclassified papers, except those presented in the state-of-the-art sessions.

— *m w j* —

MOTOROLA SUPPLIES RADIO RELAY SYSTEM

A microwave radio relay system for use in transmitting data between computers has been supplied the Control Data Corp. by Motorola, Inc., Chicago, Ill.

The microwave test system is being used to connect computers between Control Data Corp. offices in Minneapolis, Minn. Length of the system is approximately 1-1/2 miles.

Connected by microwave are Control Data's Computer 1604 and its smaller model 160 which is being employed as a satellite computer unit. Test data is being transmitted at the rate of approximately 200,000 characters per second.

Motorola has supplied its recently-introduced MR-40 equipment, a new 12,000 megacycle microwave receiver-transmitter that provides broad-band communications, especially suited for high speed data transfer.

— *m w j* —

COHN NAMED CHAIRMAN OF IRE COMMITTEE

Stanley I. Cohn, assistant director of electronics research, Armour Research Foundation of Illinois Institute of Technology, has been appointed chairman of the Radio Frequency Interference Committee of the Institute of Radio Engineers.

Cohn received notice of his appointment in a letter from IRE president Lloyd V. Berkner. His appointment will run from May 1, 1961 until April 30, 1962.

— *m w j* —

HUGGINS CONTRACTED BY SANDERS

Huggins Laboratories, Inc., Sunnyvale, Cal., a microwave vacuum tube laboratory, has received a sub-contract for the amount of approximately one-half million dollars from Sanders Associates, Inc., Nashua, N. H.

The contract calls for the delivery of traveling wave tubes for use in a microwave system designed by Sanders Associates for the U. S. Navy.

Huggins Laboratories has been working with Sanders Associates on the development of this traveling wave tube for the past year, relating to modification of electrical characteristics, ruggedization, and temperature compensation. Manufacture of the initial contracted units has started, and production will increase each month to reach peak delivery by June 1961.

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FINANCIAL NEWS

VARIAN FIRST QUARTER SALES INCREASE

Varian Associates, Palo Alto, Cal., has announced increased sales and earnings for the first quarter of its 1961 fiscal year. Sales increased 18 per cent to $12,747,932 compared to $10,795,951 for the first quarter of 1960. Earnings were $865,008, up 11 per cent, or 26 cents per share on 3,374,695 shares, up from the $776,710 or 24 cents per share earnings on fewer shares during the comparable period one year ago.

In making this announcement, H. Myrl Stearns, President, noted that progress in the high power tube field was particularly gratifying. Production of tubes for high power radar and communication systems is increasing rapidly.

— m w j —

NATIONAL RESEARCH REPORTS 1960 SALES

National Research Corp., Cambridge, Mass., has announced in its annual report recently that total sales for 1960 reached an all-time high. Earnings were significantly higher and the company realized the highest operating profit in its 20-year history, president Hugh S. Ferguson stated in the letter to stockholders.

Net earnings after taxes were $255,000, equivalent to 48 cents per share for 1960, as compared with $17,400 or 3 cents per share for 1959. Sales of products, research services and income from licensees totaled $9,176,400, an increase of 33 per cent over the preceding year.

— m w j —

AEL DECLARES DIVIDEND

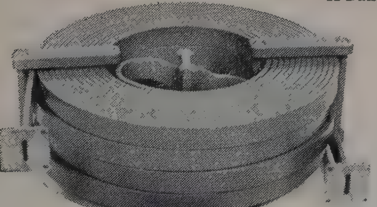
AEL, Inc., Philadelphia, Pa., has announced the declaration of a dividend at a meeting of shareholders.

Dr. Leon Riebman, president, announced that the Board of Directors had declared a 10 per cent stock dividend on February 24, 1961 to all shareholders of record on January 25, 1961. It represented the first dividend paid by this ten-year old company.

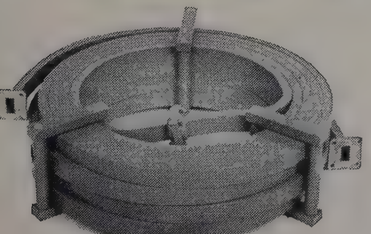
AEL, Inc., is active in research and development programs in the microwave component and antenna fields and in the production of communications and medical electronic equipment.

— m w j —

X Band



X$_L$ Band



K Band

MICROWAVE DELAY LINES
where accuracy counts

In delay lines, where exacting design and construction standards apply, look to Turbo.

Turbo designs are available, with complete testing, for both fixed and variable systems, for waveguide and coaxial lines, from 1 to 26 kmc, from 0.01 to 2.5 microsecond. Write for complete specification and price data for standard units. Or ask about special designs involving problems of space, configuration, and performance.

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TURBO

ALFORD
rf instruments and co-axial components

New Miniature Hybrids
120-240 mc model, for example, is only 4″ x 4″ x 1″ (approx.) exclusive of external matching cables. Isolation over 45 db; VSWR 1.45.

Slotted Lines
Residual VSWR of the line itself is under 1.01. Rated error in detected signal is under 1.005. Standard slot lengths are 20, 40, 60, 80, and 130 inches. These lines are available with a wide variety of interchangeable precision tapered reducers for measurements in different types of rigid and flexible coaxial lines.

Line Stretchers
Low VSWR; rugged and dependable — built for long service; several ranges of adustment. Available in nearly all transmission-line sizes up to 1⅝″.

Automatic Impedance Plotters
Display impedance-vs-frequency curves on a self-contained 5″ CRT and on an external X-Y recorder (not supplied). Frequency ranges are 0.1 — 2.5 mc, 2.5 — 250 mc, 30 — 400 mc, 180 — 1100 mc, 1100 — 1700 mc. Made in portable and rack-mounted units.

Other Products
- Tapered Reducers
- Line Stretchers
- Hybrids
- Adjustable Matching Networks
- Impedance-standard Lines
- VOR Antennas
- TV Broadcasting Antennas — directional and omnidirectional
- Diplexing Filters
- Vestigial Sideband Filters

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PROFESSIONAL PLACEMENT

NEEDED: more Electronics Engineers qualified to work on advanced missile detection systems

Complexity of, for example, the BMEWS project, indicates the need for experience, competence...highlights the kind of opportunities open with General Electric's Missile Detection Systems Section.

FUTURE DEFENSE, SPACE PROBLEMS

Future-generation space vehicles will necessitate even more sophisticated detection systems. The creation of such systems is the job of the Advanced Radar Systems Development Engineer. Qualifications are high . . . but the rewards are in keeping—the opportunities for advancement excellent.

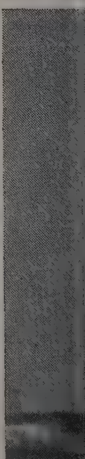
Within the next ten years the need for qualified engineers and scientists will quadruple in the field of missile, space-probe and satellite detection. This prediction is made by General Electric's Missile Detection Systems Section, based on present and anticipated space vehicle state-of-the-art.

And because of this, there is a possibility that a technical manpower "vacuum" may develop in what many consider to be one of the most vital, fast-growing technologies of the space age. What's needed are more engineers who can meet the strict requirements. For example . . .

It takes a unique kind of engineer to work in the field of detection. An Advanced Systems Engineer must be extremely competent technically. Yet, he must also be something of a "dreamer"—able to anticipate and define future *problems* as well as conceive practical systems *solutions*. To do this, he must keep abreast of virtually every significant advancement, not only in his own, but in other fields.

The same holds true for Equipment Specialists who must meet exacting detection-system specifications. Yet, there are relatively few related fields where this kind of specialized experience can be obtained.

BMEWS is a good example of the magnitude of system and equipment requirements. Its 66,000 square-foot antenna reflectors had to be engineered to hold a ¾ of an inch tolerance over a 150° tem-



PROVIDING 15-MINUTE WARNING

BMEWS' massive radar reflectors are indicative of the system's complexity. According to MDSS four electronics engineers will be needed within the next decade for every one now working on such systems.

REPORTS FOR ELECTRONICS ENGINEERS

perature range . . . with a 2-inch tolerance in winds up to 185 mph. Its radar detection sub-system, designed and developed by G.E.'s Missile Detection Systems Section, transmits multi-million watt pulses . . . to receive milli-micro-microwatt echoes. And this is just one part of a complex system to detect missiles, calculate trajectory, impact area, impact time, and point of launch.

It's indicative of why the Missile Detection Systems Section can offer growth opportunities in a technology that has some of today's most unique engineering and scientific challenges.

IMMEDIATE OPENINGS FOR SYSTEMS EXPERIENCED ENGINEERS AND SCIENTISTS

General Electric's Missile Detection Systems Section has openings right now for qualified scientists and engineers anxious to broaden their experience and continue their professional careers in this exciting new technology. Although requirements are necessarily high, the opportunities for rewards and advancement are unusual.

DEFINING FUTURE SPACE PROBLEMS . . .

. . . is the job of the *Advanced Radar Systems Development Engineer.* There is an immediate need for competent men to conceive detection systems that will outpace the most advanced state-of-the-art in missiles, space-probes and satellites.

Advancement is in keeping with the highly demanding nature of this position. Your responsibilities will include determining broad parameters for—and establishing feasibility of—advanced detection systems. Basic requirements include a BSEE, an advanced degree, and five to ten years' experience in systems design and analysis.

PROVIDING HARDWARE SOLUTIONS . . .

. . . for future detection systems is the job of the Systems Analysis Engineer. A high degree of technical competence and the ability to manage are prerequisites. In this position you will specialize in evaluating missile defense systems and coordinating the tools and talents of the organization in order to obtain optimum configurations based on utility, performance, cost and delivery.

Basic requirements include a BSEE degree, Physics, or Math. You should be familiar with mathematical probability, systems simulation, operational analysis, and generalized harmonic analysis.

PROGRAMMING COMPLEX DATA . . .

. . . is the challenging job of the Senior Programmer in Computer Operations. This job requires an ability to interpret problems related to analysis of missile detection systems. As group leader, you will be responsible for computer programming and other detailed investigations.

Basic requirements include a BSEE or Math degree, with three to five years of experience on large scale scientific computers.

INSTALLATION, CHECKOUT AND INTEGRATION . . .

. . . must be successfully accomplished by the Systems Engineer working at the installation site. As such, you will be responsible for actual system installation, checkout, and integration with all other systems or subsystems. Your job will include initial operation of the system and training of operating personnel. Rewards are in keeping with the highly demanding nature of this position.

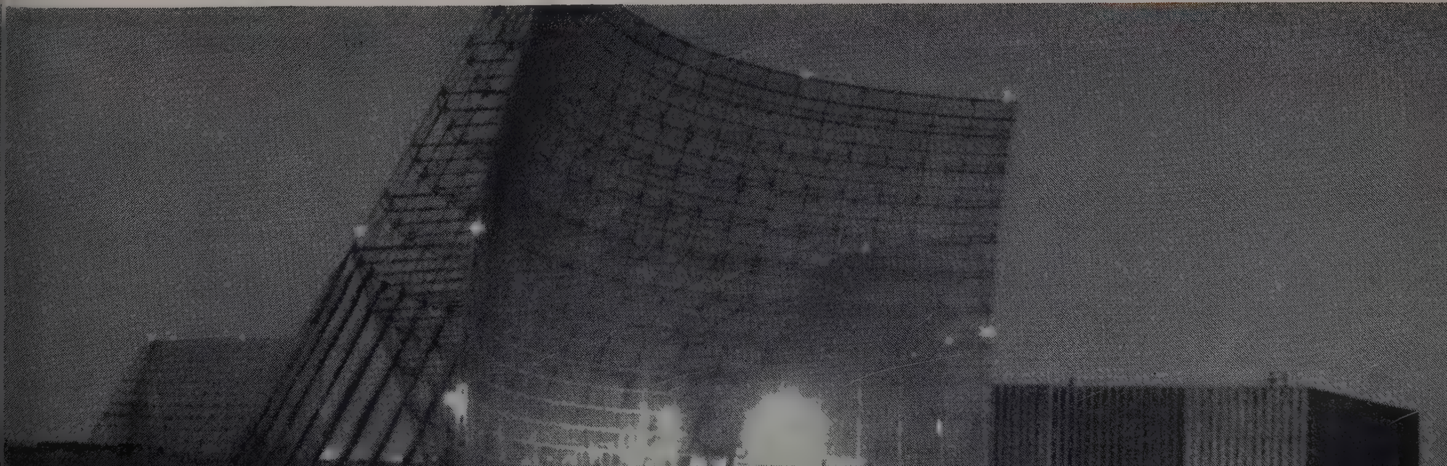
Basic requirements include a BSEE degree with five years' experience in radar, high power transmitters and/or microwave systems. 177-44

FOR MORE INFORMATION:

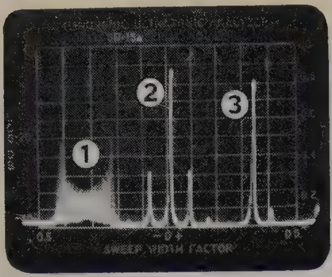
or for a copy of this new brochure which describes the challenging and rewarding opportunities open to you in General Electric's Missile Detection Systems Section, write today to:

Mr. Dana S. Brown
Missile Detection Systems Section T-14
General Electric Company
Court Street, Syracuse, N. Y.

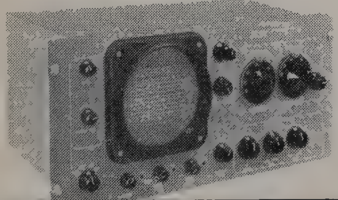
GENERAL ELECTRIC



Lab setup shows SB-15a versatility. (1) FM display measures dynamic deviation. (2) and (3) are AM and SSB signals, respectively, with sine wave modulation.



MORE ULTRASONIC ANALYSES *faster easier high accuracy*



PANORAMIC'S NEW, IMPROVED SB-15a spectrum analyzer 0.1 kc to 600 kc

Find, identify and analyze more types of ultrasonic signals with Panoramic's advanced Model SB-15a . . . economical, compact and completely self-contained.

• Noise, vibration & harmonic analysis • Filter and transmission line checks • Telemetry analysis • Communication System Monitoring . . . and more—Power Spectral Density Analysis and Frequency Response Plotting (with companion equipment).

SB-15a specifications:

• *Frequency Range:* 0.1 kc to 600 kc • *Sweepwidth:* variable, calibrated from 1 kc to 200 kc • *Center Frequency:* variable, calibrated from 0 to 500 kc • *Markers:* crystal controlled at 10 kc and 100 kc intervals • *IF Bandwidth:* variable, 100 cps to 4 kc • *Sweep Rate:* variable, 1 cps to 60 cps • *Amplitude Scales:* Lin, 40 db log (extendable to 60 db), 2.5 db expanded • *Sensitivity:* 200 μv to 200 v full scale • *Accuracy:* ± 0.5 db.

Write today for detailed technical data on the SB-15a . . . NEW CATALOG DIGEST . . . and regular mailing of THE PANORAMIC ANALYZER, featuring application data.

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NEW LITERATURE

HIGH POWER ELECTRONIC DATA SHEETS ISSUED

A series of High Power Electronic data sheets is now being issued by FXR, Inc., Woodside, N.Y., through the company's High Power Electronics Division. Under the category of High Voltage Regulated Power Supplies, three sheets illustrate and give full technical specs for Model Z850A, O-12KV Main Supply with optional focus and filament supplies; Model Z851A, 2-10KV Anode Supply with optional bias and filament supplies; Model Z852A, O-18KV Main Supply with optional focus, magnet, and filament supplies.

The fourth sheet covers the 50 Megawatt S-Band Klystron Transmitter as well as its remote control console. All sheets are coded with reverse block headings, by instrumentation types, for ease of filing and category identification. These Data Sheets are available on request by specifying the model number.

— *m w j* —

AIRBORNE AND GROUND COMMUNICATION DESCRIBED

Wilcox Electric Co., Kansas City, Miss., has announced a catalog titled "Modern Aviation Electronics," describing in picture and brief description its airborne and ground communication and navigation equipment, as well as its line of Magnetic components.

The 44-page booklet is pocket-size, available upon request.

Circle Reader Service Card 171

— *m w j* —

CATALOG REVIEWS "CONHEX" SUB-MINIATURE R.F. CONNECTORS

A 12-page catalog of fast assembly "Conhe*X*" sub-miniature r.f. connectors for RG and other coaxial cables, along with a nationwide listing of stocking distributors, is available from Sealectro Corp., Mamaroneck, N.Y.

Gaining wide usage for applications from prototype to plant-scale, the 50-ohm and 75-ohm connectors are available in both screw-on or snap-on series, as either cable clamp or cable crimp type. 75-ohm "Conhe*X*" connectors may be used with either 90-ohm or 95-ohm coaxial cable with no serious impedance mismatch.

In addition to "Conhe*X*" plugs, jacks, bulkhead receptables, feed-thrus, right angle units, cable terminations, tee adaptors, and printed wiring board units, the catalog describes broad lines of adaptors, BNC and TNC plugs.

Circle Reader Service Card 172

— *m w j* —

BARNSTEAD BULLETIN DESCRIBES WATER DEMINERALIZERS

Bulletin # 154, available from Barnstead Still and Sterilizer Co., Boston Mass., introduces a complete line of disposable cartridge-typewater demineralizers for use in chemical, hospital, electronic, nuclear, laboratory research, and pilot plant operations.

These demineralizers feature disposable cartridges in models up to 1500 gallons per hour. They include: standard bantam demineralizers; pressure-type bantam; two stage-type purifier, which may include a demineralizer cartridge in series with an organic removal or oxygen removal cartridge. Special rinse water purification loops are described such as are used in electronic ultra-high purity rinse systems.

Also shown are interchangeable standard cartridges, mixed resin cartridges, oxygen removal cartridges, organic removal cartridges and cation cartridges. The BD-10 demineralizer is listed with cartridge flow rates up to 1500 gallons per hour. Other small regenerative type demineralizers and research demineralizer kits are included.

Circle Reader Service Card 173

— *m w j* —

COMPLETE LINE OF FILM RESISTORS DESCRIBED

An eight-page 1961 Catalog is now available from Pyrofilm Resistor Company, Inc., Parsippany, N. J. It describes the company's complete line of precision deposited carbon film resistors for commercial, sub-miniature, MIL type, high resistance, high voltage and microwave resistor applications.

Circle Reader Service Card 174

— *m w j* —

HEWLETT-PACKARD PUBLISHES APPLICATION NOTE

A four-page application note describing a convenient accurate method of making VLF frequency comparison measurements with Hewlett-Packard laboratory equipment is now available from Hewlett-Packard Co., Palo Alto, Cal.

The Application Note, No. 50, illustrates the equipment setup and describes measuring techniques for obtaining accuracies of one part in 10^9 or higher in one hour using VLF standard broadcasts. Longer comparison periods increase the accuracies proportionally.

Circle Reader Service Card 175

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(*Continued on page 140*)

Abstracts from *Russian Technical Literature*... of interest to microwave engineers

Translations of complete papers can be made available by contacting Morris D. Friedman, Inc., c/o "the microwave journal," 1330 Beacon Street, Brookline, Massachusetts. Prices are dependent upon length of paper.

IVUZ, RF, 3(4): 656-666 (*1960*)
V. M. Kontorovich:

ON THE THEORY OF THE TRAVELING WAVE MASER.

The dependence of the gain coefficient of a maser with a traveling surface wave on the dispersion properties of the retarding system is discussed. For paramagnetic system in which resonance occurs for a circularly polarized magnetic field, the maximum surface wave gain is achieved at the greatest retardation in the phase velocity. Hence, the gain coefficient of the counter surface wave tends to zero. The retarding system is described by using the effective surface impedance. An expression is obtained for the mean density of the wave energy taking account of the energy stored in the retarding system.

IRFE AN UkrSSR (*2F, 11R*)

—m w j—

IVUZ, RF, 3(5): 737-745 (*1960*)
V. O. Rapoport:

ON THE GROWTH OF ELECTROMAGNETIC WAVES IN A STREAM MOVING IN A PLASMA IN THE PRESENCE OF A MAGNETIC FIELD.

The problem is considered of the growth of electromagnetic waves in a plasma through which a plasma stream moves along the lines of force of a constant magnetic field. It is assumed that thermal scatter of the velocities in the stream is nonexistent. Growth coefficients of the electromagnetic waves are found in the case of Cherenkov radiation.

NIRFI GOR'KII UNIV. (*3F, 6R*)

—m w j—

IVUZ, RF, 3(4): 614-618 (*1960*)
N. S. Zinchenko; A. Ia. Usikov:

MILLIMETER BAND RADIOWAVE REFLECTION FROM A SNOW LAYER.

Experimentally obtained values of the millimeter band radiowave reflection from a snow layer are presented. The reflection coefficients refer to broad wavelength (five wavelengths) and angle of incidence ranges (from 30 - 80°). An explanation is given of the anomalously low radiowave reflection from the lower part of the millimeter band which is detected.

IRFE AN UkrSSR (*8F, 4R*)

—m w j—

IVUZ, RF, 2(4): 683-693 (*1960*).
V. S. Il'in:

VARIATIONAL METHOD OF COMPUTING SYMMETRIC FOUR-TERMINAL NETWORK INHOMOGENEITIES IN RECTANGULAR RADIO WAVEGUIDES.

On the basis of a variational method, a "four-terminal network" inhomogeneity in a rectangular waveguide in the form of a lattice diaphragm of arbitrary thickness is considered. The general formulas obtained describe the great number of inhomogeneities often encountered in microwave waveguide engineering.

SATAROV UNIV. (*3F, 7R*)

—m w j—

IVUZ, RF, 3(4): 606-613 (*1960*)
A. E. Salomonovich; O. M. Ataev:

THERMAL EMISSION AND ABSORPTION OF RADIOWAVES IN THE 8 MM BAND IN THE TERRESTRIAL ATMOSPHERE.

Values are presented of molecular absorption of 8 mm radiowaves, obtained from data on the measurement of the intrinsic thermal emission of the terrestrial atmosphere. A spherically symmetric model of a humid atmosphere in which absorption and dissipation of the radiowave energy in the condensed phase is not taken into account, is used in determining the absorption coefficients. For clear days, which are described well enough by this model, the following values of the absorption coefficients are obtained in oxygen and water vapor, respectively: $k_{01} = 0.0046$ neper/km $= 0.04$ db/km and $k_{02} = 0.00046$ neper/km $= 0.004$ db/km per 1 g/m^3. The results obtained permit an appraisal of the total absorption of radiowaves of the 8 mm band according to the magnitude of the absolute humidity of the air and according to the distance traversed by the radiowaves in the terrestrial atmosphere.

FIAN (*7F, 12R*)

—m w j—

IVUZ, RF, 3(4): 667-671 (*1960*)
V. S. Troitskii; N. M. Tseitlin:

METHOD OF MEASURING THE ANTENNA SCATTERING COEFFICIENT BACKGROUND NOISE. ABSOLUTE MEASUREMENTS OF THE MICROWAVE BACKGROUND INTENSITY.

A method is proposed for the measurement of the antenna scattering coefficient and its noise caused by the emission of external media in the antenna side lobes. Conditions are considered for the exact measurement of the background intensity.

NIRFI GOR'KII UNIV. (*3R*)

—m w j—

IVUZ, RF, 3(3): 452-455 (*1960*)
V. A. Malyshev:

EXPERIMENTAL VERIFICATION OF THE THEORY OF MICROWAVE OSCILLATORS WITH A RESONANT LOAD.

Results are presented of an experimental verification of the basic formulas of the theory of microwave oscillators with a resonance load using a reflex klystron.

TAGANROG UNIV. (*4F, 1R*)

—m w j—

TRAK Type
9127-SL(CW),
tunable 2.15—
2.45 KMc

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This MINIATURE TRAK Type 9127-SL(CW) Microwave Cavity is ideal as a local oscillator or low power transmitter in the new 2.2—2.3 KMc telemetry band. With a power output in excess of 100 mw, it is also suitable for use as a parametric pump, or the energy source for harmonic generators.

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CW Power Out	Greater than 50 mw over entire tuning range Greater than 100 mw over 2.2—2.4 KMc range
Power Input	150 VDC at 10 ma and 6.5 V at 240 ma
Temperature Stability	Less than 1 Mc drift with a temperature variation of 80°C. Operable from —70° to +120°C.
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Weight	7 ounces

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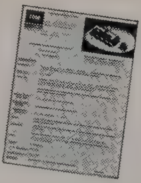

New Literature

(Continued from page 138)

BROCHURE ILLUSTRATES SLIP-RING ASSEMBLIES

A three-page brochure, illustrating typical precision slip-ring and commutator assemblies is available from Occo Manufacturing Corp., South Hackensack, N.J.

The assemblies are utilized in applications requiring high reliability, environmental capabilities and extreme dimensional criteria.

Among these applications is a precision assembly installed deep within the gear train of a helicopter engine to provide continuous temperature readout of the various gear train elements to a remote location.

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—*mwj*—

DATA SHEET REVIEWS VARIED SUBJECTS

The Industrial Products Division of the Hamilton Watch Co., Lancaster, Penn. announces a new loose leaf data file containing technical data sheets which illustrate and describe the broad range of high precision manufacturing abilities of this division.

The data sheets review in pictures such subjects as plate processing, toothed wheels and gears, pinions and arbors, small screws and threaded parts, flat and irregular shaped parts, along with sheets on supporting services offered.

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—*mwj*—

TECHNICAL OPERATIONS PUBLISHES MILITARY OPERATIONS RESEARCH BROCHURE

A new ten page brochure on war gaming and military operations research has been published by Technical Operations, Inc., Burlington, Mass.

Called "Trends in Military Operations Research" the booklet covers the development of a soldier-scientist relationship in operations research, the urgent need for data, and war gaming as a partial substitute for field experience. It also points out the increasing need for the synthesis of accumulated knowledge of military operations research.

"Trends in Military Operations Research" was originally given as a paper at a national meeting of the Operations Research Society of America by Dr. Donald W. Meals, manager of branch operations for Technical Operations.

Two branch offices of Technical Operations conduct military operations research in the Combat Operations Research Group, functioning as scientific advisor to the Continental Army Command, and OMEGA, which produces a two-sided global air-war game for the Air Force.

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—*mwj*—

Career Opportunities for

MICROWAVE ENGINEERS IN NEW TI PRODUCT MICROWAVE GROUP

The activation of a new microwave product group at Texas Instruments Apparatus Division has opened up several ground-floor opportunities for qualified microwave engineers. Assignments include project responsibility.

REQUIREMENTS: Degree (preferably advanced) in EE, ME or physics. Minimum of 3 years experience in one or more of the following areas: microwave systems analysis; low-noise receiver design; development of such microwave systems components as parametric and tunnel diode amplifiers, harmonic generators, ferrite devices, mixers, IF preamplifiers, filters, switches, cavities utilizing waveguide, strip transmission line, and coaxial techniques; design of solid-state precision oscillators and stable reference sources; phase-locked systems; voltage-tuned oscillators; and signal generators.

Send confidential resume including work accomplishments (name specific microwave experience) to

JOHN PINKSTON, Dept. 5 PROFESSIONAL PLACEMENT

TEXAS INSTRUMENTS INCORPORATED
APPARATUS DIVISION
6000 LEMMON AVE.
DALLAS 9, TEXAS

ENGINEERED PLASTIC PRODUCTS DESCRIBED

Bulletin 611, (4-page), from Polystructures, Inc., Stoneham, Mass., describes the capabilities and facilities of the company and explains typical applications of plastic products with controlled properties, that can be manufactured to MIL Specifications. Products that can be made by Polystructures, Inc. include specialized items such as radomes, plastic antennas, parabolic dishes, microwave lenses, encapsulation and potting of electronic components, as well as structural plastic panels for shelters and unusual shapes for modern architectural design applications. Packaging and shipping containers are also mentioned in the bulletin.

It also includes tables giving typical mechanical properties of glass-fibre-base polyester laminates and rigid Polyurethane foam.

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— *m w j* —

MICROWAVE BROCHURE AVAILABLE

A twelve-page Antenna and Microwave Brochure is now available on request from AEL, Inc., Philadelphia, Pa.

The brochure describes AEL's line of microwave products including antennas and components as well as custom developments and systems. Detailed data on a line of Solid State devices such as RF switches, limiters, attenuators, harmonic generators and crystal detector mounts is included.

Information is included on integrated systems such as panoramic receiving systems, susceptibility analyzers and a line of video amplifiers.

The Antenna and Microwave brochure may be obtained free of charge by contacting AEL, Inc.

Circle Reader Service Card 180

— *m w j* —

MICROFLECT MANUAL DETAILS USE OF PASSIVE REPEATERS

A new 48-page "Passive Repeater Engineering Manual" No. 161, intended for use by Microwave Systems engineers and others concerned with the application of Passive Repeaters, is available from Microflect Co., Inc., Salem, Oregon.

The manual describes, in detail, the use of passive repeaters and provides the technical data necessary to properly design passives into the microwave systems. Complete specifications on Microflect Company's line of passive repeaters for systems from 2000 Mc to 12,000 Mc are included as well as sample calculations to clearly illustrate the technical information contained in the manual.

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— *m w j* —

(*Continued on page 142*)

Engineers MICROWAVE TUBE

Engineers with B.S., M.S. or Ph.D. degrees in physics or related fields are invited to investigate the opportunities currently existing at the Hughes Microwave Tube Division in Southern California.

Select fields of interest include:

- high-powered periodically focused traveling-wave amplifiers,
- lightweight low noise amplifiers for broad band receivers,
- multielement phased array amplifiers,
- low drainage satellite communication tubes

Additional, specific openings exist for **Application Engineers** and **District Sales Managers.**

For immediate consideration, write or call collect: A. F. Heilman, ORchard 0-1515, Extension 5792

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announces New Opportunities for

MICROWAVE ENGINEERS

Accelerated growth of scientific activity at Westinghouse Electronic Tube Division in Elmira, N. Y. has created outstanding career opportunities for experienced MICROWAVE ENGINEERS. Salaries are open, depending on experience and qualifications. Delightful community for work and recreation in Finger Lakes region of upstate New York.

IMMEDIATE OPENINGS:

- Sr. MAGNETRON ENGINEER with production or project supervisory experience.
- Sr. MECHANICAL ENGINEER with design experience for electronic tubes.
- Sr. ENGINEER for microwave devices (filters and reference cavities).
- Sr. ENGINEER experienced in high power transmitting Traveling Wave Tubes.
- Sr. ENGINEER experienced in fast recovery TR tubes.
- Sr. ENGINEER with Klystron design or manufacturing experience.

Write or send resume to: Mr. William Kacala, Technical Recruiting
P.O. Box 284, Dept. C-2, Elmira, N.Y.
or phone collect Elmira, REgent 9-3611

Westinghouse
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UNITED STATES
FOR

- RADIO RELAY SYSTEMS ENGINEERS
- RADIO RELAY ENGINEERS
- RADIO ENGINEERS
- MULTIPLEX ENGINEERS
- POWER ENGINEERS
- MICROWAVE TECHNICIANS
- SPECIFICATION WRITERS

U.S. CITIZENSHIP REQUIRED
(Families May Accompany)

Submit detailed resumé of schooling and experience and specific salary requirements to

Box A-47
The Microwave Journal
P.O. Box 300
Brookline 46, Mass.

MARKET RESEARCH ASSOCIATE

Position currently open in Ohio corporate office of multi-plant manufacturing firm. Experience requirements: 5-10 years in market and product research, preferably with 2-3 years in electronics industry or closely allied fields. Also require above average ability to write concise reports and recommendations. Preferred academic background: Electrical Engineering degree, supplemented by graduate study in marketing. Confidential interviews will be arranged promptly for qualified candidates. Request that initial reply include complete background details and also state current compensation requirements.

Box A-10
The Microwave Journal
P.O. Box 300
Brookline 46, Mass.

New Literature

(Continued from page 141)

ADVANCED SYSTEMS LABORATORIES GROWTH DESCRIBED IN BROCHURE

A two-color illustrated brochure describing the growth and development of Sanders Associates, Inc., Nashua, N.H., and particularly in Burlington, Mass., in the electronics industry has been issued, according to an announcement by Martin R. Richmond, Sanders Vice President.

The brochure also deals with the founding of the company in 1951 and its rate of growth which has consistently shown a doubling in size every two years since its inception.

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— *m w j* —

BROCHURE DESCRIBES SILICON ALLOY MATERIALS

A four-page brochure devoted entirely to the technical details of its line of Silicone Alloy materials for microwave and other electronics applications was recently issued by Isolantite Manufacturing Corp., Stirling, N.J.

Technical data on two types of Isolantite Silicone Alloys including their physical as well as electrical properties is contained in a full page, easy to read chart. These materials lend themselves for use in a wide variety of insulators. Isolantite's engineering department is available for consultation on both standard and custom manufactured insulators.

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— *m w j* —

BROCHURE COVERS MANUFACTURING FACILITIES

The Bart Manufacturing Corp., Newark, N.J., has published an eight page brochure covering the various aspects of its research, development, design, and manufacturing facilities for industry.

The brochure discusses the Bart Manufacturing and associated companies' facilities and long experience in electroplating and electroforming; its Lectro-Clad nickel-plated steel process; precision tube bending, forming and machining; manufacture of microwave components; sheet metal fabrication, and other precision production manufacturing.

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VARIAN ASSOCIATES

Instrument Division has a position in their branch office at Kenilworth, New Jersey for a laboratory electromagnet systems Applications Engineer. The candidate selected will call on scientists in the finest academic, industrial and government laboratories throughout the Eastern United States. Candidate should have demonstrated considerable responsibility and initiative in previous positions and should have a degree in science or engineering with above average academic standing. Position requires a man of highest integrity, an intensive interest in scientific activities, and a strong desire for technical sales work.

Send resume to:

TECHNICAL EMPLOYMENT DEPARTMENT

VARIAN
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611 Hansen Way Palo Alto, Calif.

Microwave Manager

This position should present a real challenge to a creative Senior Microwave Engineer interested in trail blazing activity with a company whose phenominal growth (from 11 engineers to 1600 employees in 9 years) is based on original technical achievements such as TRI-PLATE® microwave components and techniques, FLEXPRINT® flexible printed circuits and PANAR® radar.

The man selected must be capable of both technical and administrative supervision. He will have an extensive microwave systems design background and be able to direct engineering activities in microwave systems for radar and missile applications — standard components and stripline techniques including antenna systems and stripline modules. At the same time, he will be expected to spark and direct sales activity in the microwave field.

If this opportunity sounds like your type of job, send a brief resume indicating salary requirements to R. W. McCarthy.

SANDERS ASSOCIATES, INC.
NASHUA, NEW HAMPSHIRE

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A message of significance to the leading microwave scientists of TOMORROW ...a message you should act on TODAY!

Sylvania's Microwave Device Operations on the San Francisco Peninsula now has programs of advanced development underway in the microwave device field. This work offers a rare opportunity to outstanding microwave specialists—an opportunity to assume overall responsibility for exploration in the fields of high power traveling wave tubes employing periodic structures, high power klystrons, and ferrite devices. The men who carry these programs forward should preferably have a Ph.D and several years of relevant experience.

You are invited to investigate now by writing to Dr. J. S. Needle at the address below. (Similar opportunities in the field of magnetrons and special purpose tubes also exist at the Microwave Device Operations in Williamsport, Pennsylvania.)

MICROWAVE DEVICE OPERATIONS

P. O. BOX 997, MOUNTAIN VIEW, CALIFORNIA

SYLVANIA

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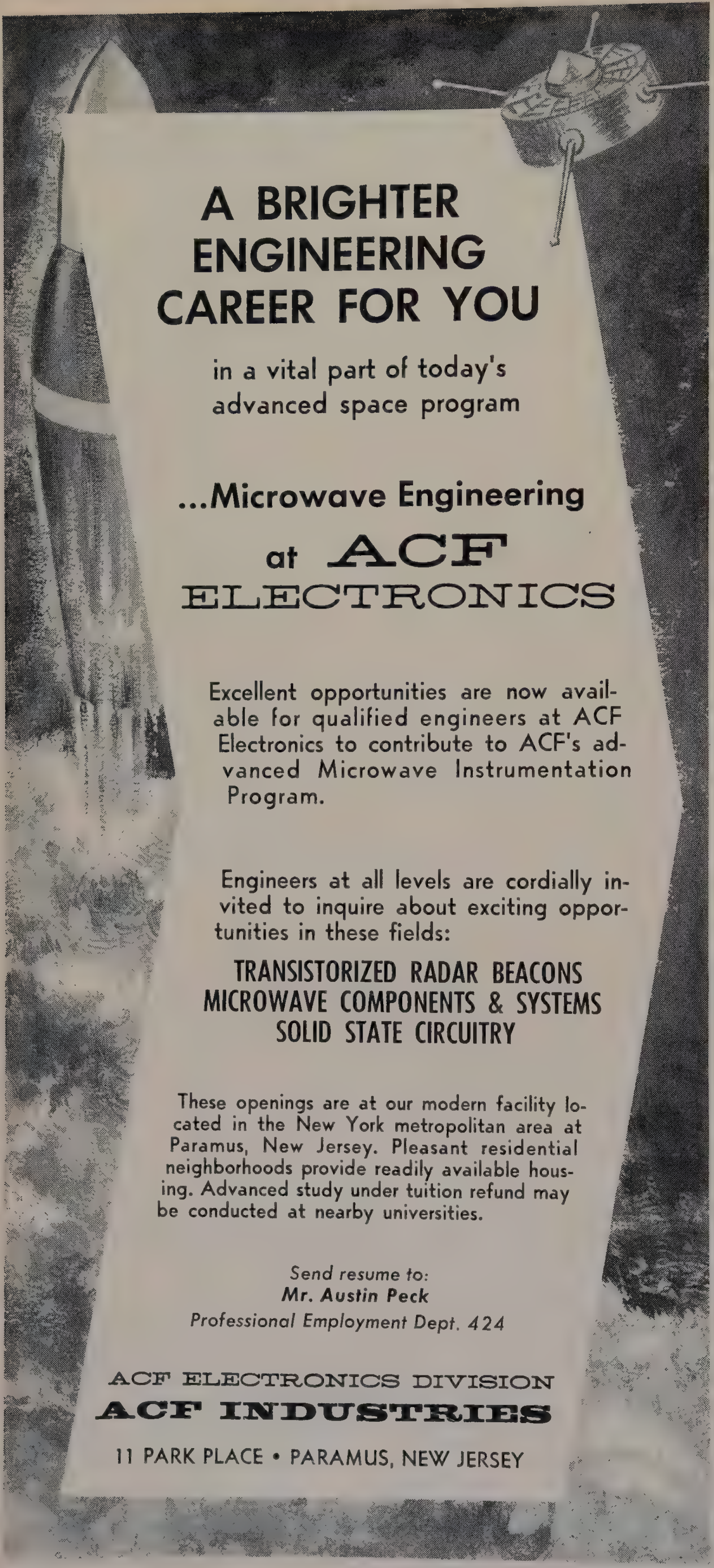

A BRIGHTER ENGINEERING CAREER FOR YOU

in a vital part of today's advanced space program

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Excellent opportunities are now available for qualified engineers at ACF Electronics to contribute to ACF's advanced Microwave Instrumentation Program.

Engineers at all levels are cordially invited to inquire about exciting opportunities in these fields:

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MICROWAVE COMPONENTS & SYSTEMS
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These openings are at our modern facility located in the New York metropolitan area at Paramus, New Jersey. Pleasant residential neighborhoods provide readily available housing. Advanced study under tuition refund may be conducted at nearby universities.

Send resume to:
Mr. Austin Peck
Professional Employment Dept. 424

ACF ELECTRONICS DIVISION
ACF INDUSTRIES

11 PARK PLACE • PARAMUS, NEW JERSEY

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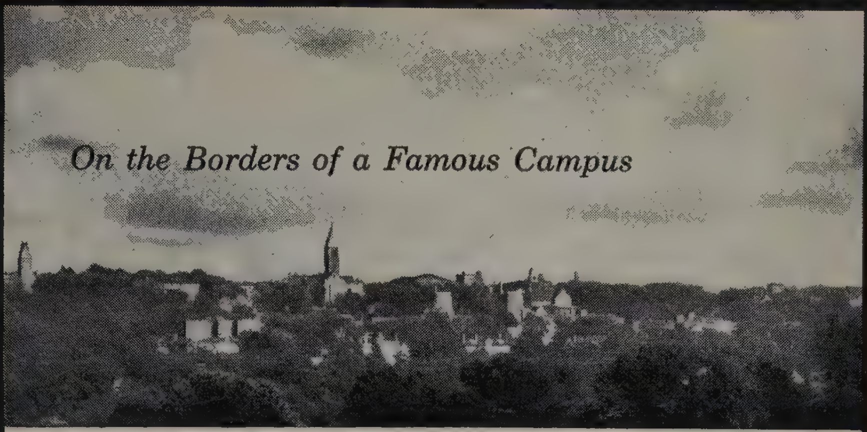

A New Multi-Million Dollar Research Facility Constructed by General Electric's Advanced Electronics Center at Cornell University

The location of GE's Advanced Electronics Center at Cornell University's Research Park was not a happy accident, but a pre-planned arrangement to permit the University and the Company to cooperate together to their mutual advantage. Ties are close. Many Cornell faculty members act as consulants to GE – GE engineers take courses – some have taught – at the University (GE's tuition refund program is a generous one). The cultural advantages of a great University – the lectures, the concerts, the libraries and galleries are immediately available to GE scientists.

NEW RESEARCH FACILITY

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Please write in full confidence to Mr. George Travers, Div. 127-MP

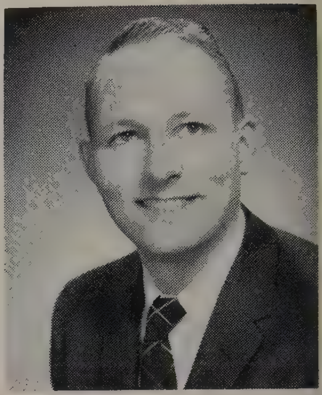
ADVANCED ELECTRONICS CENTER AT CORNELL UNIVERSITY
General Electric, Ithaca, New York

LIGHT MILITARY ELECTRONICS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC

" . . THE IRE . . . COULD EXERCISE SOME RESTRAINT AND CAUTION ON THE . . . FORMATION OF CONVENTIONS. "

conventions at the crossroads



ROBERT C. HANSEN, ASSOCIATE EDITOR, *the microwave journal*

At this time, when most everyone in the microwave business is sampling the annual IRE-PGMTT National Symposium, I'd like to think over this convention business. It seems that conventions follow some sort of Parkinson's Law: they have grown in size and number since the war, somewhat independent of conditions in the electronics industry! There are so many now that an electronics engineer could hardly attend all if he did nothing else. Over a general background of complaints that there are too many low-grade conventions, one hears that the PGMTT Symposium is one of the very best. It might be fun to speculate on the reasons. Most important I believe is that PGMTT represents a relatively small, highly specialized field, where many of the active participants know each other. The highly technical nature of the Symposium does not lend itself well to exhibits, so there are no displays to compete with the technical program and with the informal sessions. The gathering together to have chats in the hallways, talking to those who have made the recent technical advances, and of course hearing papers, seem to breed a feeling that the microwave people belong to a closely knit family. Further, the unusually high quality of the papers stimulates both attendance and attendees. Whether I've hit the correct reasons or not, the PGMTT Symposium leaves one with pleasant memories.

Not all conventions fare so well. The low average quality of papers at some conventions has not been unremarked. There are just not enough good papers for all. To get a better picture of the convention business, let's look into the types and number of conventions. Conventions can be classed in two ways: as general or specialized, and with or without trade shows. First it might be interesting to speculate why conventions are started. One important function, which was probably responsible for the early conventions, is to serve as a forum for the interchange of information on all phases of the state of the art. There are three large shows of this kind: the IRE National Convention, WESCON, and the National Electronics Conference. Another reason for conventions is to assemble together specialists in a specific field. Most of the conventions are of this type. A strong factor toward increasing the number of these is that each of the 28 IRE Professional Groups represents either a specialty, or a specific horizontal grouping, and each tends to "want their own show". Some PG's have no convention, some jointly sponsor with a non-IRE group, some have a convention all alone, as does PGMTT. At least one PG even has two annual conventions! In addition, there are many other societies with interests in the electronics field: AIEE, American Physical Society, URSI, etc. Meetings have also been regularly sponsored by MIT and Polytechnic Institute of Brooklyn, to mention only two universities. Possible exhibit profits and organizational prestige present a meretricious picture to the group thinking of starting a new convention, and once a convention is started, it seems to perpetuate itself. Of course, often a useful purpose is served by such a continuance, but sometimes an organization feels it would lose face by chopping off a convention. This is like installment buying: it appears desirable until one is involved; after the fact, there is a natural reticence to disclose the difficulties that have ensued. So another annual convention is established.

With this in mind, let's look at how many conventions there are, and what the cost and benefit of them is. To give an idea of the choice available to microwave people, I will list all of the 1960 events I could find that pertained to the microwave business. Some of these are general technical meetings, some rather specialized, all are in the U.S.A. A few are regional so that here there is overlap. There are 37 meetings listed! In spite of the size of the list, not included are specialized conventions dealing with such areas as reliability, engineering management, education, writing and speech, although microwave people may be vitally interested in these also!

Jan. 31 - Feb. 5	New York	AIEE Winter General Meeting
Feb. 3 - 5	Los Angeles	Winter Convention on Military Electronics
Feb. 10 - 12	Cleveland	Cleveland Electronics Conference
March 21 - 24	New York	IRE National Convention (Annual)
April 20 - 22	Houston	SWIRECO (Annual)
May 2 - 4	Dayton	National Aero Electronics Conference (NAECON) (Annual)
May 2 - 5	Washington, DC	URSI-IRE Spring Meeting
May 3 - 5	San Francisco	WJCC
May 9 - 11	San Diego	PGMTT Annual Symposium
May 24 - 26	Seattle	7th Region IRE Conference
June 1 - 3	Ann Arbor	University of Michigan Radar Symposium
June 13 - 14	Washington, DC	RFI Symposium
June 19 - 24	Atlantic City	AIEE Summer General Meeting
June 22 - 24	Boulder	IRE Electronic Standards and Measuring Conference
June 23 - 24	Lafayette, Ind.	Workshop on Solid State Electronics
June 27 - 29	Washington, DC	Fourth National Convention on Military Electronics
July 24-Aug. 19	Boulder	American Math Society, Modern Physical Theories and Associated Math
Aug. 1 - 3	Washington, DC	Fourth Global Communications Symposium
Aug. 8 - 12	San Diego	AIEE Pacific Meeting
Aug. 23 - 26	Los Angeles	IRE WESCON (Annual)
Aug. 29-Sept. 1	Los Angeles	AFBMD-STL Symposium on Ballistic Missiles & Space Technology
Sept. 9 - 10	Cedar Rapids	Conference on Communications
Sept. 19 - 22	Washington, DC	Symposium on SET (Annual)
Sept. 21 - 22	Cleveland	Industrial Electronics Symposium
Sept. 28 - 30	Ann Arbor	Annual Symposium on Electronic Warfare
Oct. 3 - 5	Utica	IRE Sixth National Communications Symposium
Oct. 4 - 6	Chicago	Sixth Conference on RFI
Oct. 9 - 14	Chicago	AIEE Fall General Meeting
Oct. 10 - 12	Chicago	NEC (Annual)
Oct. 12 - 14	Monterey	APS Thirteenth Annual Gaseous Electronic Conference
Oct. 24 - 26	Baltimore	East Coast Aeronautics and Electronics Conference
Oct. 27 - 29	Washington, DC	Electron Devices Meeting
Nov. 14 - 17	New York	Sixth Conference on Magnetism & Magnetic Materials
Nov. 14 - 16	Kansas City	Mid-America Electronics Convention (MAECON) (Annual)
Nov. 15 - 17	Boston	Northeast Electronics Research & Engineering Meeting (NEREM) (Annual)
Dec. 12 - 14	Boulder	URSI-IRE Fall Meeting (Annual)
Dec. 13 - 15	New York	EJCC (Annual)

It is interesting to note that for this particular compendium, the favored locales are Washington, D. C., and New York. Also the big surge occurs in May, June, and October. Although Washington meetings followed the May-June-October peak, none of the New York meetings occurred during these three peak months. Further, all New York meetings were during the winter; I prefer spring and fall in New York myself. Well, statistics of small samples are usually odd.

Mass statistics are currently very popular: one is supposed to say something like "microwave engineers spend X millions of man-hours and Y dollars attending technical conventions". Such mass statistics are often worthless. One can generally get little useful information on how many billions of dollars were spent for, say, education in the USA; the important facts are the amount per pupil and the amount per person. Similarly for conventions. If a microwave engineer attended one of the big three general conventions, the PGMTT Symposium (of course), one regional show, and one other specialized convention from the many on the list, he would spend about 13 working days at the four. However, travel usually allows each three or four-day convention to occupy a full work week. Thus, about four weeks would be involved in attending these four conventions, or 8% of the work year! Now if we assume that an average engineer, plus overhead, costs 25 kilobucks yearly, the convention-going costs a round two kilobucks not including travel, which could easily add another. This is a reasonable sum for a company to invest each year in an experienced engineer. Benefits of technical and professional stimulation from paper sessions and informal discussions at a good convention are invaluable, and what better way is there to keep current on the art. However, it is doubtful that all electronic engineers indulge in four conventions per year. One or two per annum would probably cover most of us.

In addition to the time of the attendees, the convention requires much work and time to be expended by the host committee in planning and operating the meeting. If a trade show is included, space purchasers must be found. The shortage of papers of quality, and the fact that companies can afford to exhibit at only a few shows means that mediocrity will be common and that all but the larger shows will have to scramble to fill the exhibit tents and the program sheet.

It seems that the time has arrived when responsible people from all walks of the industry, and this is by no means just the microwave industry, need to look carefully at the proliferating technical conventions. Those groups considering the initiation of a convention or continuing an old one should ask themselves what it will contribute, how it overlaps with other conventions, whether the manpower employed in running the convention could be more profitably employed for the profession in some other way. Exhibitors should (and probably do, since money is directly involved) pick only a few shows of high technical quality. Paper givers and convention attenders should likewise be more careful of their valuable time. If the number of conventions were reduced to a more desirable number, say half, some good papers would go unread. The IRE could help here by assisting the several Transactions to publish more of these high quality papers. At least one Group has an acceptance ratio well below 50%, and this prompts many authors to send their papers to a convention for recognition which in turn helps to increase the number of conventions. Some of the papers should just quietly be dropped, of course. Unfortunately, the IRE seems at this time to be taking steps towards reducing the financial support for Transactions publications, rather than increasing it. Estimates are that 80% of the electronics industry is supported by NASA and DOD funds. In these times when the general business future is uncertain, it might be wise to support fewer conventions of higher quality. This would also better serve the defense and space objectives of the USA.

The observation has often been made that it is much more difficult to stop something than to start it, especially in volunteer societies. What can really be done? Well, the IRE, through the Board of Directors and through the Professional Groups Committee, could exercise some restraint and caution on the promulgation and formation of conventions. Similarly the AIEE could do likewise, and could refrain from trying to start new meetings in clear competition with already established meetings. I make these remarks with some knowledge of the convention business, having worked on such as WESCON, RTCA Symposium, PGMTT Symposium, and PGMIL Convention. Good conventions are definitely beneficial both to those who work and those who just attend, and with a judicious discontinuance of the "goats", conventions will serve those in the electronics field even better.

* * *

This new logo for our **microwave engineers' handbook and buyers' guide** will be getting around to more than 22,000 qualified microwave engineers and management people.
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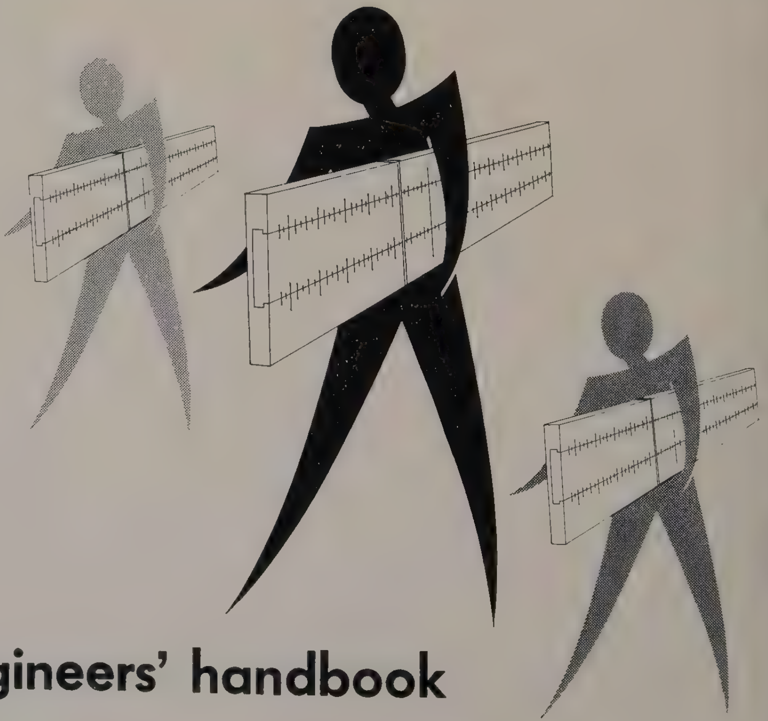

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Complete this section if you are principally engaged in COMPONENTS: 0-29

-65 ☐ **Antennas**
1-65 ☐ Large 3-65 ☐ Small (Under 12')
-65 ☐ Communication 0-66 ☐ Tropo Scatter
-65 ☐ Tracking 1-66 ☐ Airborne
-65 ☐ Detection 3-66 ☐ Other ——— **Specify**

-67 ☐ Instruments ——— **Specify**

-67 ☐ **Tubes** 7-68 ☐ Storage
-67 ☐ Planar 9-68 ☐ Gaseous Discharge
-68 ☐ Passive devices 0-69 ☐ Magnetron
-68 ☐ Klystron 1-69 ☐ BWO
High or low power 3-69 ☐ TWT
3-68 ☐ 5-68 ☐ 5-69 ☐ Other ——— **Specify**

-70 ☐ Solid State 7-71 ☐ Masers
-70 ☐ Amplifiers 9-71 ☐ Diodes
-70 ☐ Transistors 0-72 ☐ Ferrimagnetics
-70 ☐ Paramagnetic 1-72 ☐ Parametrics
-70 ☐ Thermoelectric 3-72 ☐ Crystals
-71 ☐ Ferrites ——— **Type** 5-72 ☐ Infrared
7-72 ☐ Other ——— specify
3-73 ☐ Transmission Lines
5-73 ☐ Transitions
7-73 ☐ Coaxial
9-73 ☐ Waveguide Adapters

0-74 ☐ **Small Components**
1-74 ☐ Bolometers 3-75 ☐ Filters
3-74 ☐ Holders & Mounts 5-75 ☐ Attenuators
5-74 ☐ Horns 7-75 ☐ Limiters
7-74 ☐ Hybrid Junctions 9-75 ☐ Diplexers
9-74 ☐ Isolators 0-76 ☐ Terminations
0-75 ☐ Gyrators 1-76 ☐ Other ——— **Specify**
1-75 ☐ Switches
9-76 ☐ **Waveguides**
0-77 ☐ Rigid 1-77 ☐ **Flexible**
3-77 ☐ **Windows**

If you are principally engaged in component activity, Tubes, Antennas, Hardware, etc.:

1. Is your principal activity to develop and/or manufacture components for direct sale? ——Yes ——No
2. Is your principal activity to produce and/or develop components for in-company systems manufacture?
   ——— Yes ——— No
3. If your answer to Question #2 is "Yes" please specify system or field of activity.
   ____
   ____

Complete this section if you are PRINCIPALLY engaged in any activities listed below. 0-33

-78 ☐ Millimeter ——— **Specify**
7-78 ☐ Infrared ——— **Specify**
3-79 ☐ Magnetics ——— **Specify**
9-79 ☐ Cryogenics ——— **Specify**
3-86 ☐ **Plastics**
5-86 ☐ **Radomes** 0-87 ☐ Dielectrics
7-86 ☐ Insulation 1-87 ☐ Absorbers
9-86 ☐ Packaging 3-87 ☐ Others ———
5-87 ☐ **Materials** 0-88 ☐ Metal Production
7-87 ☐ Garnets
9-87 ☐ Germanium 1-88 ☐ Ferrites
3-88 ☐ Arsenide
5-88 ☐ Inter Metallic Compounds
7-88 ☐ Rubies
9-88 ☐ Other ———

0-89 ☐ Plasma
1-89 ☐ Ionized gases
3-89 ☐ Other ———
5-89 ☐ Spectroscopy
7-89 ☐ Optics
9-89 ☐ Nuclear
0-90 ☐ Linear Accelerator
1-90 ☐ Cyclotron
3-90 ☐ Other ———
5-90 ☐ Atomic Beams
7-90 ☐ Hermetic Seals
9-90 ☐ Other ———
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Please identify your activity as precisely as possible if not listed in above area.

If you are principally engaged in component activity:

1. Is your principal activity to develop and/or manufacture components for direct sale?
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3. If your answer to Question #2 is "Yes" please specify system or field of activity. ___________________

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1 ☐ Name ______________________ Full Title ____________
2 ☐ First Middle Initial Last

3 ☐ Company ____________________

4 ☐ Department ____________________

5 ☐ Co. Address ____________________
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Address to which you wish the journal sent—home address preferable

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If change of address, place old address below and anwser all questions completely.

Please check the areas below in which you are PRINCIPALLY engaged.

☐ Research and Development
☐ Design
☐ Executive
☐ Applications
☐ Purchasing
☐ Production
☐ Education
☐ Sales
☐ Other
☐ Manufacturers Re

Specify if you are working for a Civil ☐ or Military ☐ Agency.

Complete this section if you are PRINCIPALLY engaged in SYSTEMS. 0-25

0-26 ☐ Radar ____________
Specific Activity

1-27 ☐ Missiles ____________
Specific Activity

3-28 ☐ Tracking 5-28 ☐ Guidance

7-28 ☐ Airborne ____________
Specific Activity

3-30 ☐ Ground Support ____________
Specific Activity

0-31 ☐ ASW ____________
Specific Activity

7-31 ☐ Telemetering ____________
Specific Activity

1-32 ☐ Radiometry ____________
Specific Activity

9-32 ☐ Data Processing ____________
Specific Activity

5-34 ☐ Radio Astronomy ____________
Specific Activity

1-41 ☐ Countermeasures
3-41 ☐ Point to point Relay Links
5-41 ☐ Detection Systems
7-41 ☐ Infrared 9-41 ☐ Other ________
Type

5-42 ☐ Commercial MW Relay User
7-42 ☐ Industry served ____________

1-43 ☐ Sonar
3-43 ☐ Ultrasonics
5-43 ☐ Other________
1-44 ☐ Communications
3-44 ☐ UHF, VHF
5-44 ☐ Space Communications
7-44 ☐ Radio
9-44 ☐ Television
0-45 ☐ Receivers
1-45 ☐ Transmitters
3-45 ☐ Other ____________
0-63 ☐ Subsystems
1-63 ☐ Power Supplies
3-63 ☐ Modulators
5-63 ☐ Receivers
7-63 ☐ Other ____________

Please specify other type of system o subsystem and your particular duties o relation to it on lines below.

____

____

____

____

Name ____________________ Company ____________

Your title ____________________ No. Empl. in your Co. ____________

Would a microwave engineering handbook and catalog purchasing guide be useful in you Research and Development or design work? ________Yes ________No

Estimate the number of engineers working in microwave activities.
In your company ____________ In your department ____________

Do you make equipment purchase recommendations? ____________

If yes, what types of equipment? ____________

____

In what research project (s) are you now involved? ____________

____

What new equipment or device do you feel needs development? ____________

____

In what type of activity is your company principally engaged?
☐ Systems ☐ Components ☐ Other

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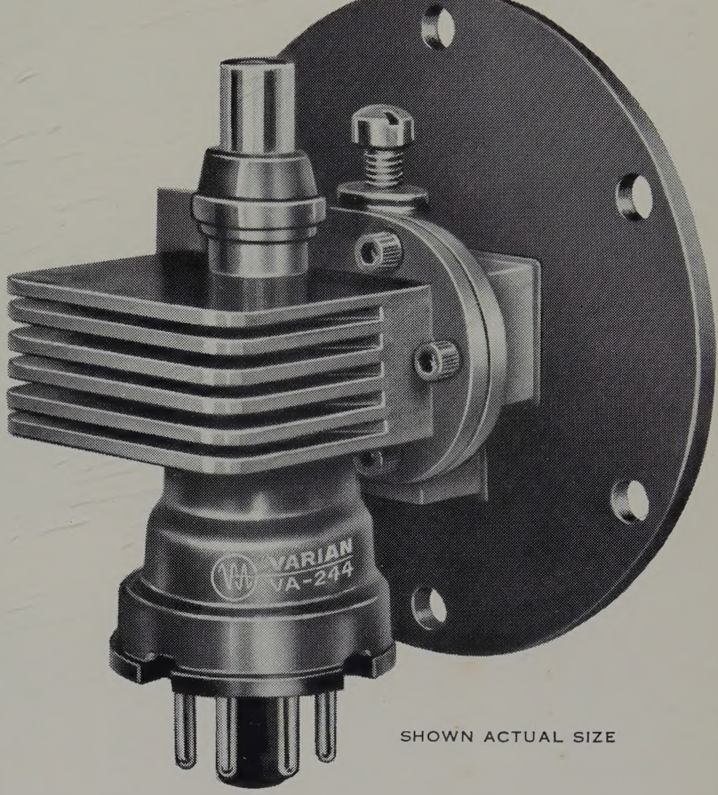
NOW 3 TUBES DO THE JOB OF 23!



SHOWN ACTUAL SIZE

FREQUENCY RANGE

TUBE #1:	VA-244A	5.8-6.6 kMc
TUBE #2:	VA-244B	6.5-7.3 kMc
TUBE #3:	VA-244C	7.1-7.9 kMc

Varian Associates' VA-244 series of reflex klystrons is designed for versatility in microwave relay applications. Three high-performance tubes can do jobs which formerly required 23 different types. They're engineered for flexibility, ideal for equipment in the common carrier bands. Series covers the microwave spectrum from 5.8 to 7.9 kMc. Use VA-244 series klystrons as transmitter tubes with average power output of 1 watt. As local oscillators, they operate at reduced voltages, with average power output of 60 milliwatts. Reliable, exceptionally stable, fully conduction-cooled. Low FM distortion, improved single-screw tuning.

The versatility of the VA-244 series minimizes manufacturers' and customers' stocking problems. Order in quantity to take advantage of price reductions. For technical data, write Tube Division.

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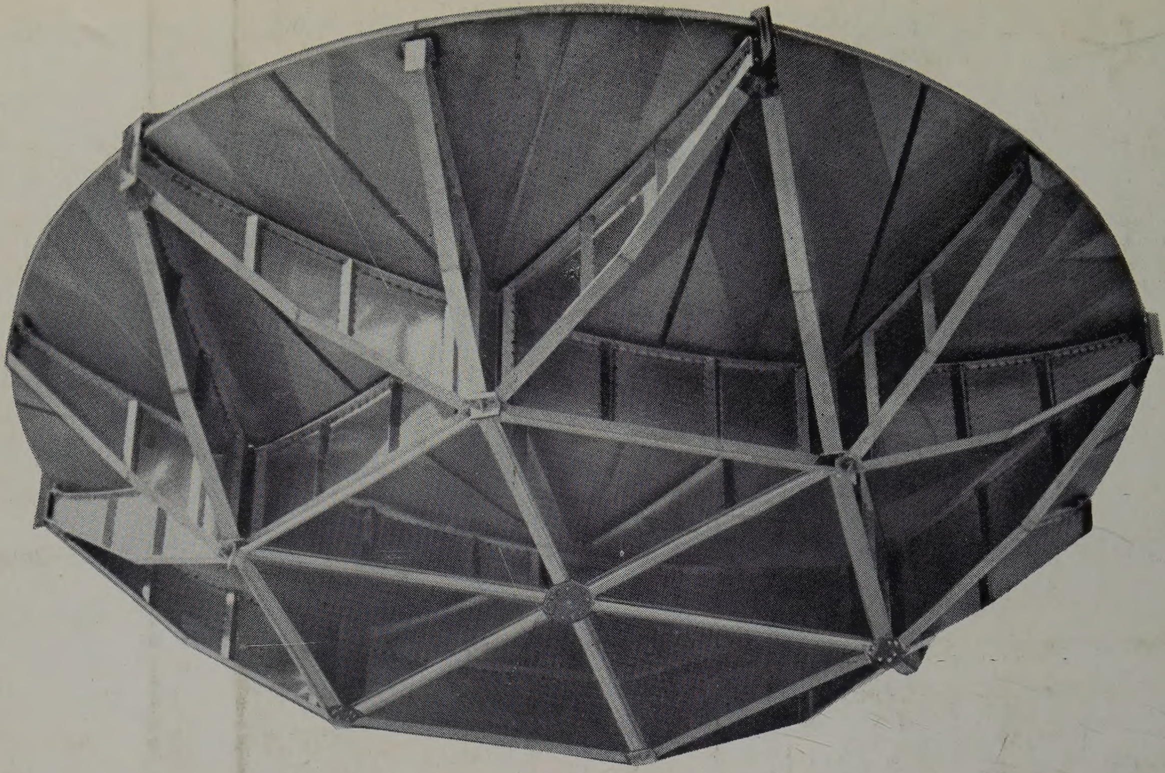


PRECISION, TOO, IS MORE THAN "SKIN DEEP"

Antenna surfaces must meet greater and greater tolerance requirements as higher frequencies are used.

Kennedy achieved maximum surface accuracy with its SPINCASTING* — but this was only half the battle. The structure which supports such a surface must also conform to these high tolerances.

Kennedy solved this need for high strength-to-weight ratio and low cost in the backup structure of a reflector with the Model 1214 reflector pictured.

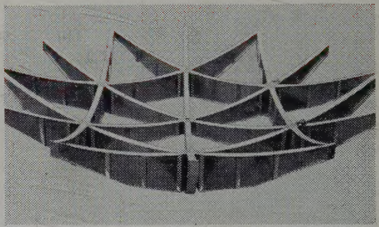
Not only is this structure ideally suited to support the SPINCASTING surface, it has also been built — as shown — with molded solid surface panels of honeycomb-sandwich construction. This surface easily meets tolerance requirements for X-Band.

SPECIFICATIONS:

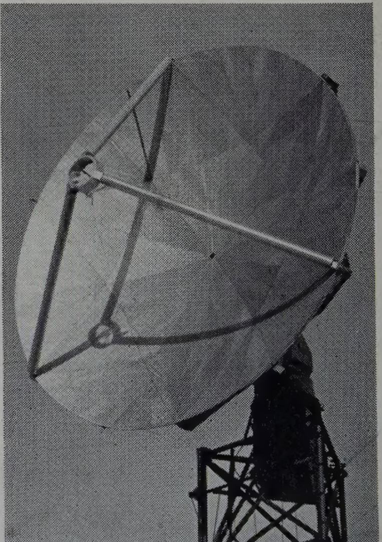
Size:	28′ to 30′
Design:	Radial tangential ribs of aluminum girders
Surfaces:	Triangular molded honeycomb panels for X-Band SPINCASTING solid surface above X-Band
Surface Tolerances:	Molded panels .040″ rms SPINCASTING .007″ rms
Weights:	Structure 1780 pounds Molded panels 1410 pounds SPINCASTING 4100 pounds

Stress analysis of this structure indicates that 40 mph operating winds will deflect the surface by rms values less than the manufacturing tolerance figures given above.

*A brochure on SPINCASTING is available.



Backup structure for Model 1214 Reflector



Model 1214 Reflector on test mount

D. S. KENNEDY & CO. ANTENNA DIVISION
Cohasset, Massachusetts • EVergreen 3-1200
Anchor Metals Division, Hurst, Texas (Fort Worth) ATlas 4-2583

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